DOCUMENT RESUME

ED 162 886 SE 025 390

TITLE	An Educator's Introduction to Energy Concepts: Overview Packets.
INSTITUTION	Maine Audubon Society, Falmouth.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
BUREAU NO	522AH60802
PUB DATE	Nov 77
GRANT	G007602036
NOTE	68p.; Pages 9, 10 of "Consumption Lifestyles" section removed due to copyright restrictions; Not available in hard copy due to marginal legibility of original document
EDRS PRICE	MF-$0.83 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Conservation (Environment); *Energy Conservation; *Environmental Education; Information Sources; Instructional Materials; Natural Resources; Physics; Social Studies; *Sociocultural Patterns; *Teaching Guides
IDENTIFIERS	*Energy Education

ABSTRACT

This publication provides a broad overview of energy and related issues for teachers and others who want to improve their understanding of these issues. Included in this publication are discussions of: (1) elementary physics related to energy; (2) energy sources, including topics such as renewable and non-renewable resources and fossil fuels; (3) energy uses in the U.S.; (4) thermodynamics; (5) space heating; (6) energy conservation; and (7) socioeconomic aspects of the energy crisis. The last section entitled Consumption/Life Style is designed for social science teachers and discusses the effects of population increases on natural resources and social values. Diagrams and tables are provided to illustrate, among other things: (1) energy consumption rates of various electric appliances; (2) energy uses by economic sector; (3) U.S. energy flow from source to work and waste; and (4) the flow of energy to and from earth. (MR)

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ENERGY CONCEPTS: OVERVIEW PACKETS

This book is dedicated to Walter Burke, whose inspirational advice will be long remembered. In addition, much credit goes to Michael Lewis, Graphic Artist; Linda Suttenfield, Editor; and Charlie Wing, Consultant.

Jonathan W. Gorham
EEEP Director

November 1977
Falmouth, Maine

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The activity which is the subject of this report was supported in part by a grant from the Office of Education, U.S. Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of the Office of Education and no official endorsement by OE should be inferred.

Grant #G007602036
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CYCOTHERMONUCLEARNOMETRY
MEGA·WHATT?
hydro
GEOTHERMAL
Kilo!
heat
BTU
Power
energy
MICRO
Entropy
3X10⁵JX10÷100S-4.18X5(
energy lingo

ENERGY UNITS

Concepts:

- Power of ten notation
- Exponential functions
- Metric (International System of Units - SI) to ordinary unit (English system) conversion
- Word origins
- Ballpark figuring

INTRODUCTION

A mishmash of energy units, technical definitions, and conversion factors has discouraged many a beginning solar researcher. Trying to size a flat plate collector for your house when the data is in such varied terms as langleys/day, kW/m^2, $BTU/ft^2/hr$, and $kcals/m^2$ can become a genuine headache.

POWER OF TEN NOTATION: THE LAWS OF EXPONENTS

For any particular energy discussion, certain energy units are appropriate. Electron volts, ergs, Joules, and mQs (milliquintillions) can all be used to quantify energy. Because energy discussions often involve large numbers, the unit Joule (J) (defined as one Watt/second) is expressed in power of ten notation.

$1.054 \times 10^{18} J = 1 mQ$ or 10^{15} BTU

$1.054 \times 10^{3} J = 1$ BTU

$1.602 \times 10^{-13} J = 1$ MeV (million electron volts)

EXPONENTS AND POWERS

The exponent indicates how many times the base is used as a factor:

$(10)^3$ (exponent; base)

$= 10 \times 10 \times 10 = 1000$ (3 factors)

$10^0 = 1$

$10^1 = 10$

$10^2 = 10 \times 10 = 100$

$10^3 = 10 \times 10 \times 10 = 1000$

$10^n = \underbrace{10 \times 10 \times 10 \times}_{n \text{ factors}} \ldots\ldots = 10^n$

EXPONENT LAWS

1. $x^m \cdot x^n = x^{m+n}$

2. $\frac{x^m}{x^n} = x^{m-n}$

3. $\left(x^m\right)^n = x^{m \cdot n}$

4. $x^0 = 1$

5. $x^{-n} = \frac{1}{x^n}$

EXPONENTIAL FUNCTIONS

The potential for a massive energy crisis exists primarily because both population and world energy consumption have been increasing at a near exponential rate. Since the turn of the century, people have been doubling their consumption of electrical energy every ten years. The world's consumption of energy for industrial purposes is now doubling every ten years.

A function is exponential if it increases by the same multiplicative factor in equal intervals of time. In an exponential function the last term exceeds the cumulative total, e. g., in the series,

1, 2, 4, 8, 16 16 is greater than 8 + 4 + 2 + 1

This increase in energy consumption may have harmful side effects on the environment which we cannot now foresee. It has been suggested that if the demand for electricity continues to double every ten years, the crucial factor is probably not the supply of fuels, but rather the build-up of CO_2 and the resultant climatic changes. There is simply no way to provide for an exponentially increasing demand on finite resources.

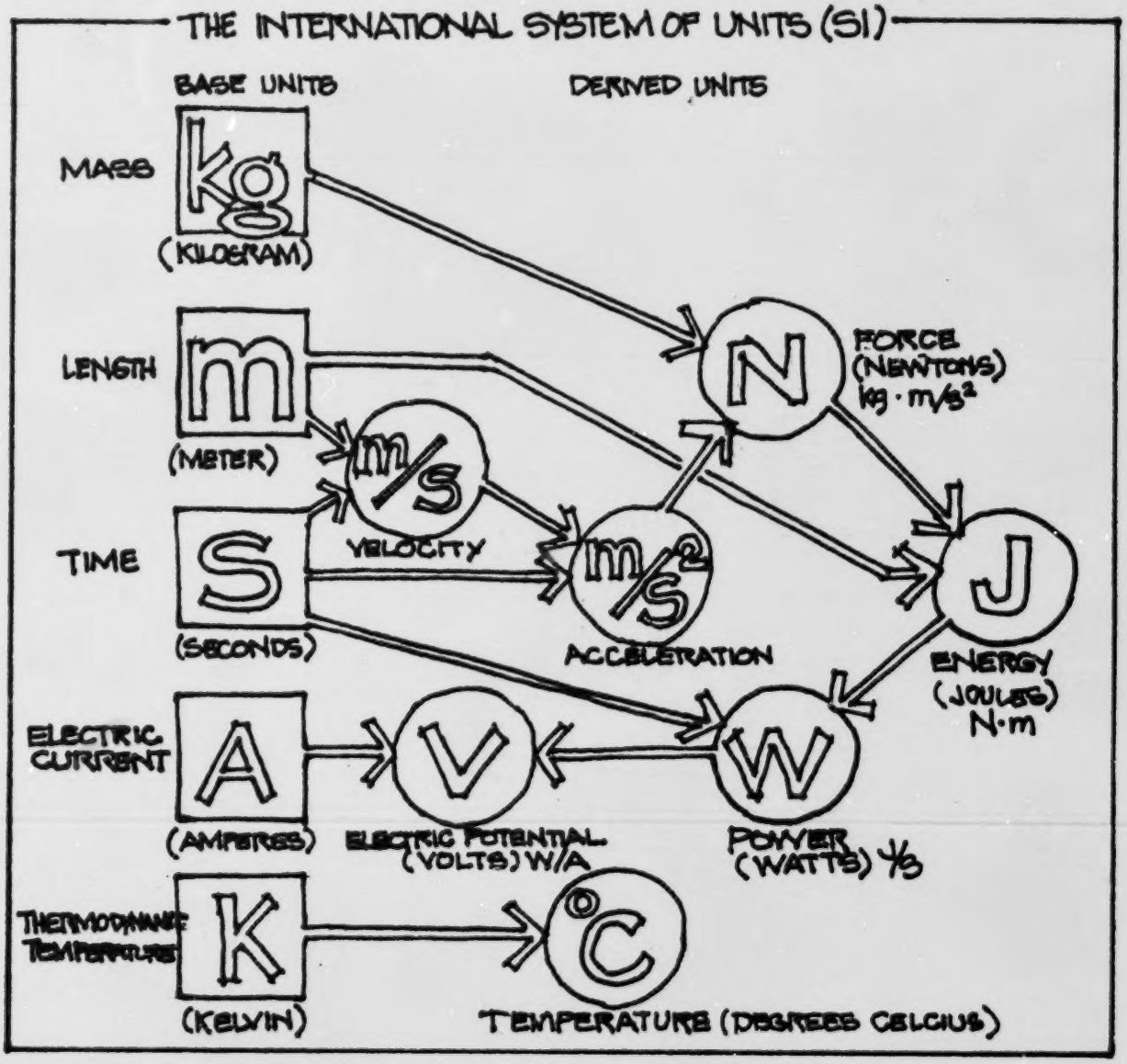
DOUBLING TIMES FOR VARIOUS RATES OF EXPONENTIAL GROWTH

Percentage increase per unit time	Doubling time
0	infinite
1	69.7
2	35.0
3	23.4
4	17.7
5	14.2
6	11.9
7	10.2
8	9.0
9	8.0
10	7.3
20	3.8
30	2.6
40	2.1
50	1.7

A rough rule of thumb to use to determine the doubling time is: doubling time $\approx \frac{70 \text{ years}}{\% \text{ annual increase}}$

UNIT CONVERSIONS

Although the term BTU (British thermal unit) enjoys widespread use in the United States today, it will eventually take a back seat to the more useful units of the metric system (SI). While not abandoning this common English unit of BTU, we recommend that the bulk of the energy calculations be carried out in metric units. Units in the English system should be re-expressed in SI equivalents to help students gain bi-system unit fluency.



ENERGY

Much of the confusion surrounding energy calculations stems from a lack of understanding of the distinction between energy and power. The standard unit for describing energy in the metric system is the Joule (J).

One Joule is defined as 1 kg $\frac{m^2}{sec^2}$

Example: we can compute the kinetic energy of a car of mass (m) 1500 kg, traveling at a speed of 20 meters/sec, by using the following equation:

$$KE = 1/2\ mv^2$$

$$= 1/2\ (1500\ kg)\left(\frac{20m}{sec}\right)^2$$

$$= 1/2\ (1500\ kg)\ 400\ \frac{m^2}{sec^2}$$

$$= 300{,}000\ kg\ \frac{m^2}{sec^2}$$

$$= 300{,}000\ Joules$$

$$= 3 \times 10^5\ Joules$$

We can see that the (KMS) units of the Joule are kg $\frac{m^2}{sec^2}$

ENERGY QUANTITIES IN JOULES

10^{24} = solar energy incident on the world in one year

10^{23} = energy available from world's fossil fuels

10^{22} = solar energy striking the surface of the U.S. in one year

10^{20} = United States energy consumed in one year

10^{18} = mQ (milli-Quint) or 10^{15} BTU

10^{11} = solar energy striking the roof of an American house per year

10^9 = barrel of oil

10^7 = pound of butter

10^6 = jelly donut

10^5 = kinetic energy of a car traveling at 20m/second

10^4 = flashlight battery

10^3 = one BTU

10^0 = 1/4 calorie

POWER

Power is the rate at which energy is expended. The Watt (W) is the standard metric system unit of power. The Watt is defined as:

one Joule/sec, or

$$1 \frac{kg\text{-}m^2}{sec^3}$$

A kilowatt (kW) is defined as 1000 Watts, or 1000 Joules/second.

If we assume that the engine of the above case produced constant power while accelerating from 0 to 20 m/sec, that it required 10 seconds to reach 20 m/sec, and that no losses were incurred due to friction, then we can calculate the power of the engine:

$$\text{power} = \frac{\Delta \text{ energy}}{\Delta \text{ time}}$$

$$= \frac{3 \times 10^5 \text{ Joules}}{10 \text{ seconds}}$$

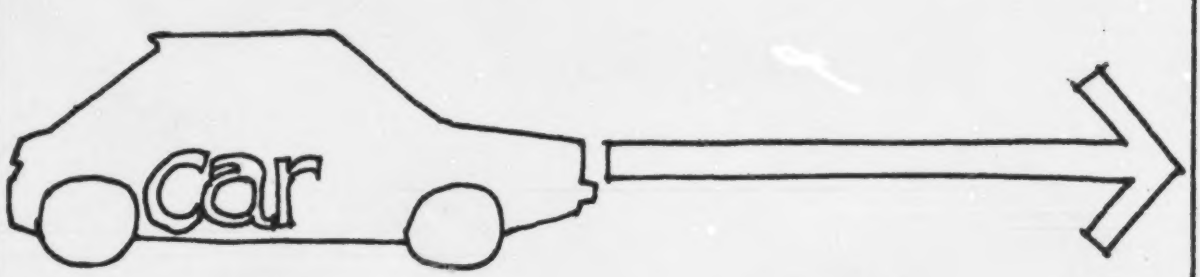
$$= 3 \times 10^4 \frac{\text{Joule}}{\text{sec}}$$

$$= 3 \times 10^4 \text{ Watt}$$

$$= 30 \text{ kiloWatts}$$

Because energy can be transformed from one form to another, (although there are subsequent losses at each exchange) we can use the energy unit Joule to describe kinetic, potential, heat and chemical energies.

CONSTANT VELOCITY • $KE = \frac{1}{2}mv^2$



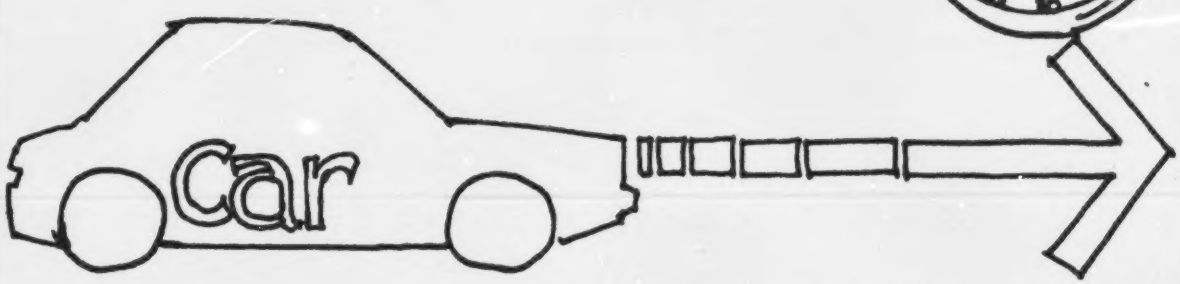
mass = 1500kg

velocity = 20 meters/second

KINETIC ENERGY (KE) = 300,000 JOULES

ACCELERATION • POWER = $\frac{\Delta \text{ENERGY}}{\Delta \text{ TIME}}$

Δtime = 10 seconds



mass = 1500kg

ΔV = 0 – 20 meters/second

POWER = 30 KILOWATTS

HEAT ENERGY

The calorie was developed to describe thermal conditions. One calorie (c) is defined as the amount of heat required to raise one gram of water one Celsius degree. Dieticians use the unit Calorie (with a capital C), which equals 1000 calories. Therefore, the Calorie, the unit commonly used in dietary studies, equals one kilocalorie. Like its English equivalent, the BTU, the calorie is anachronistic because heat energy can be expressed in Joules and Watts. Nevertheless, the popularity of the term "calorie" flourishes.

(Energy) 1 Joule = 1 kg $\frac{m^2}{sec^2}$

(Power) 1 Watt = 1 kg $\frac{m^2}{sec^2}/sec$

(Thermal Capacity) 1 calorie = 4.184 Joules

BTU

In the English system, the most common unit is BTU, or British Thermal Unit. One BTU equals the amount of heat required to raise one pound of water one Fahrenheit degree.

Three other energy terms are:

Q (Quintillion) = 10^{18} BTU

Quad = 10^{15} BTU = mQ

langley = 1 cal/cm^2 or

3.69 BTU/ft^2

All are relatively common units used in solar energy discussions.

The foot-pound and horsepower units are so cumbersome and outmoded in the solar energy vernacular that they may be ignored. Some basic conversions are listed below:

(energy) 1 Joule = 1 Watt - second

= .000278 Watt-hour

= .000948 BTU

= .239 cal

(power) 1 Watt = 1 Joule/sec

= 3.414 BTU/hr

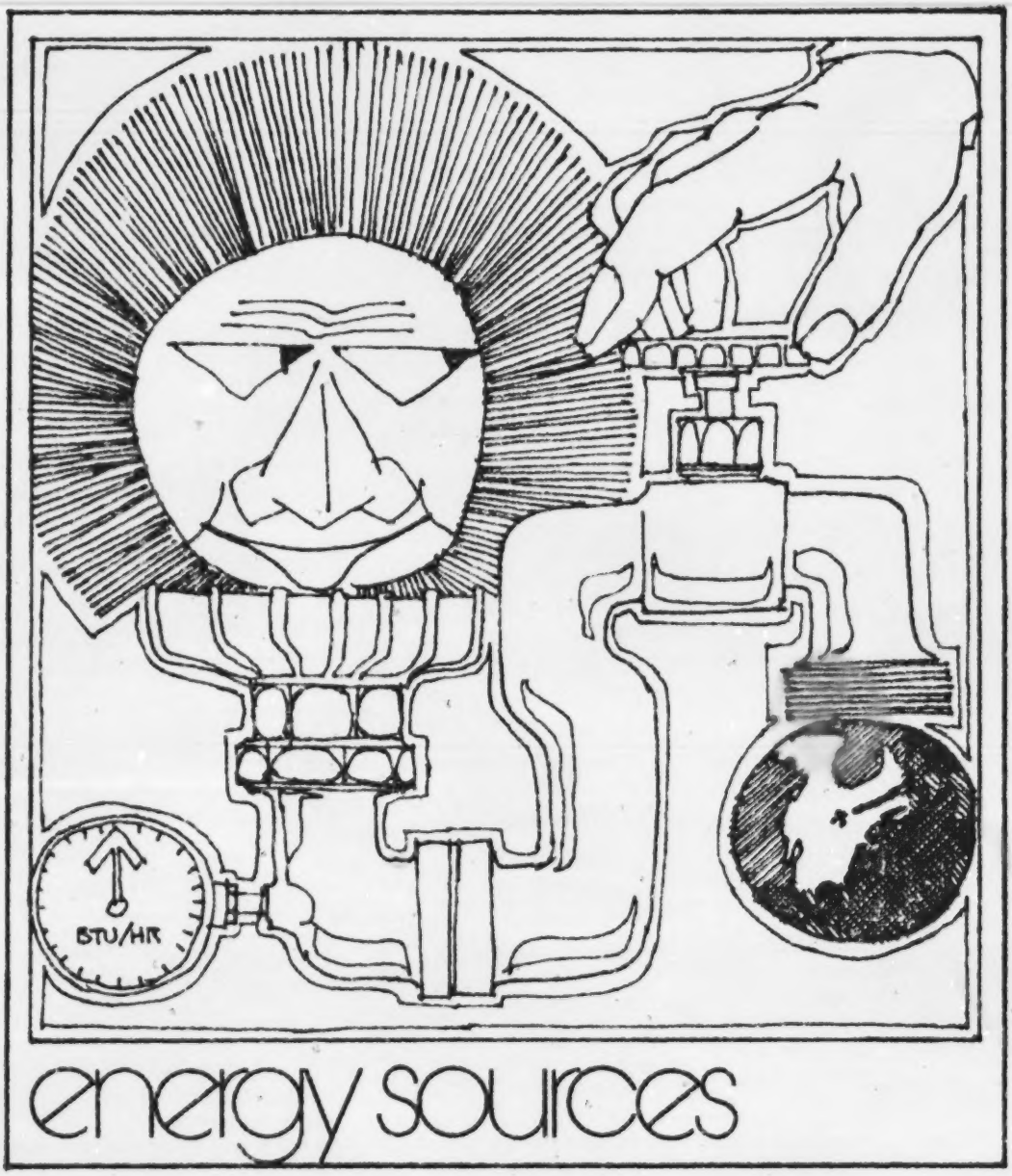
= 14.34 cal/min

CONVERSION PROBLEMS

1. A company in Augusta, Maine, sells heat reclaimers. These devices capture as much as 20,000 BTU/hour from the exhaust fumes of chimney furnaces. In Australia, the Aborigines capture heat by sleeping with their dogs. A three-dog night is one which requires that the owner sleep with three dogs in order to stay warm. If we assume that one 20-kg dog radiates about 75 Watts of thermal energy, how many Aboriginal dogs would it take to provide comparable heat to the exhaust fume reclaimer? Which type of heating would you prefer? Why?

2. Assume that an average bath tub can hold about 50 gallons of water. If we fill the tub with water at 105°F., and allow it to cool to room temperature (65°F.), how many kWhr of energy have we allowed to escape into the bathroom air? What strategy might this fact suggest in terms of saving energy during the winter time?

3. If we had a 30-sq. ft. solar water heater which converted radiant energy to heat energy at an average efficiency of 50% and radiant energy were received at the rate of 50 langleys per hour, what would be the rate of temperature increase (C°/hr.) of the 30-gallon tank?


BTU/HR
energy sources

ENERGY SOURCES

Concepts:

- Renewable vs. Non Renewable Resources
- Fossil Fuels
  - Coal, Oil and Natural Gas
- Nuclear Energy and Hydro Power
- Energy Uses and Environmental Effects
- Personal Consumption

Introduction

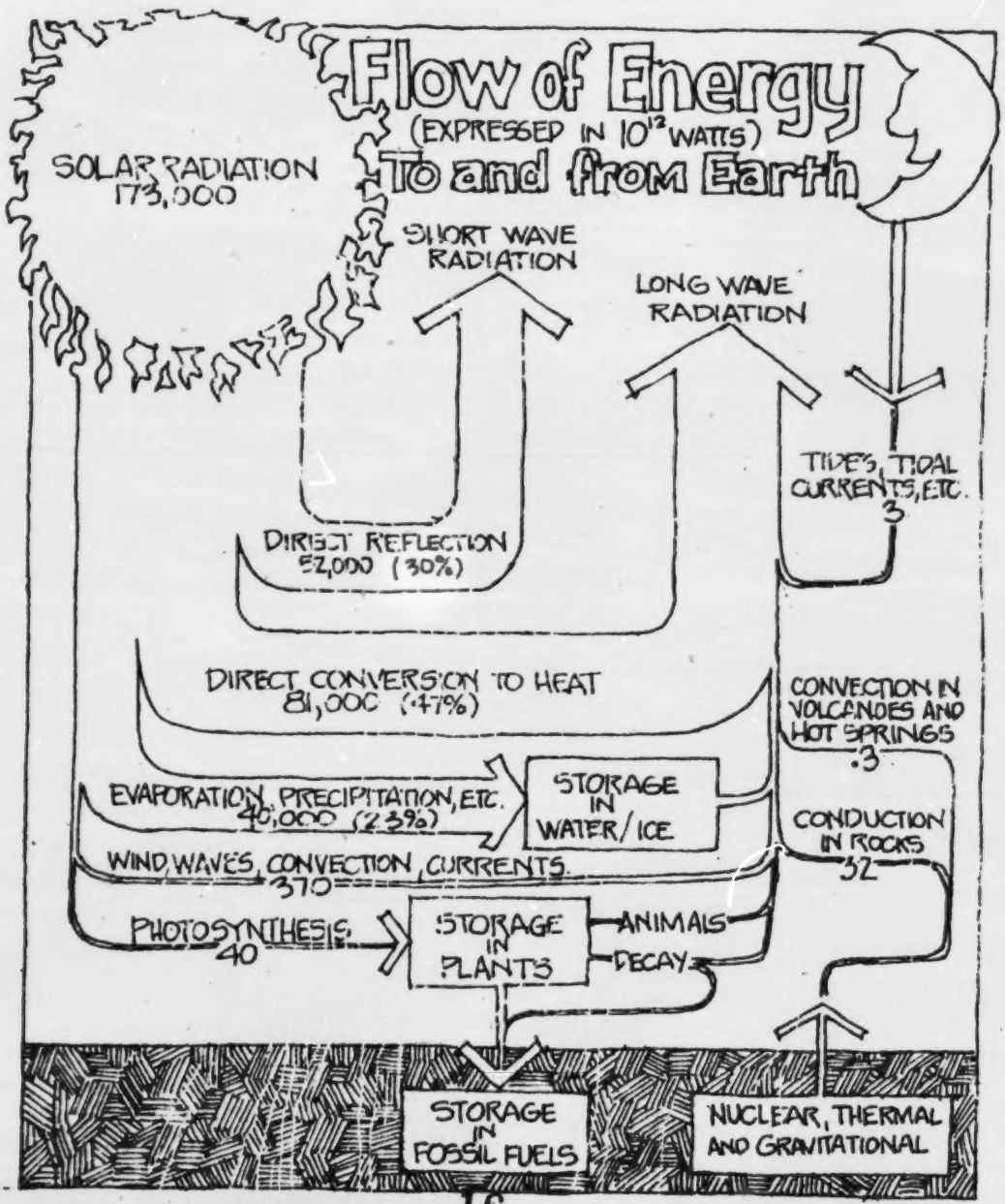
From the moment of the caveman's first fire, the availability and use of new energy sources has affected our lives. Over the past 7,000 years technologies have been developed to harness our planet's many natural energy sources. In 1,000 B. C., the Chinese inserted long bamboo tubes deep into the ground in order to extract natural gas for use in lamps. For centuries Southwest American Indians have designed houses with precise solar orientation and thermal mass for heating and cooling. In short, many of the "new" renewable resource technologies are simply the re-application of age-old knowledge.

In our feverish pursuit to amass material riches, the Western industrial societies have neglected these more appropriate and ecologically benign technologies. Yet a return to these renewable resources may come. There exists one fundamental flaw in our industrial production system: our wealth is based on the rapid depletion of concentrated forms of non-renewable resources. We are like the gluttonous consumer who prefers to withdraw money from his savings account rather than work for a week's hard won wages. Yet the energy joy ride is nearly over. With a mere few centuries we will have exhausted our planet's fossil fuel "savings", which took hundreds of millions of years to evolve. The supreme challenge for Western societies will be to orchestrate a smooth transition towards a more balanced life style in greater harmony with these renewable energy resources.

Renewable vs. Non-Renewable Sources

By definition renewable energy sources are those whose consumption can be approximately equal to the replacement capabilities of natural processes. These renewable resources fall into two rough categories:

Solar	Non-Solar
thermal energy	geothermal
electricity (photo cells)	tidal
bio fuels (photosynthesis)	nuclear fusion
wind	
water	



These renewable energy sources can be distinguised from our current sources of supply; the fossil fuels, coal, oil and natural gas. We depend on fossil fuels for approximately 97% of our energy.

The fossil fuel dependance or addiction is one which could have serious economic repercussions, as the price of extracting the last increments of fuel become prohibitively expensive. By the turn of the century, this orderly transition towards renewable energy resources must be well under way.

Fossil Fuels

Fossil fuels can be broadly classified as those naturally occurring non-renewable hydrocarbons such as coal, crude oil, or natural gas formed over extremely long periods of time from fossil fuel remains of organic materials. Although fossil fuels are continuously being produced, the rate at which they are being used so greatly exceeds their fixation that they must be considered essentially non-renewable.

Fossil fuels have been an extremely attractive energy source because of the great amount of energy stored in a very small space. Per cubic foot gasoline possesses about 10 times more BTUs than wood. In addition, oil and its derived products are excellent mobile fuels. The engineering problems of propelling an airplane on coal are overwhelming. Natural gas is an extremely clean fuel producing few harmful environmental effects upon combustion. These reasons, when coupled with its relative abundance, have made these two fossil fuels the mainstay of our economy, today providing approximately 75% of our nations energy budget. A close look at our energy sources reveals this extreme fossil fuel dependance.

Coal

Coal is the most abundant of the fossil fuels. It constitutes 90% of U. S. conventional energy reserves, but currently supplies only 18% of energy consumption. Coal can be broken down into three distinct types; bituminous (the major component), anthracite and lignite. This latter type may play a greater role in our future energy needs despite its lesser fuel value because of its abundance in the Western United States.

Coal is a complex and varied mixture of solid organic compounds. For this reason it is hard to generalize about coal as our energy resource. Its heating value, sulfur content and ash properties vary from type to type. The National Energy Plan calls for increased use of coal over the next 50 years, to the extent that 30 - 40% of our energy can come from coal. The environmental dangers of coal in use have long been known; black lung disease and sulfur dioxide air pollution are just two widely documented side effects.

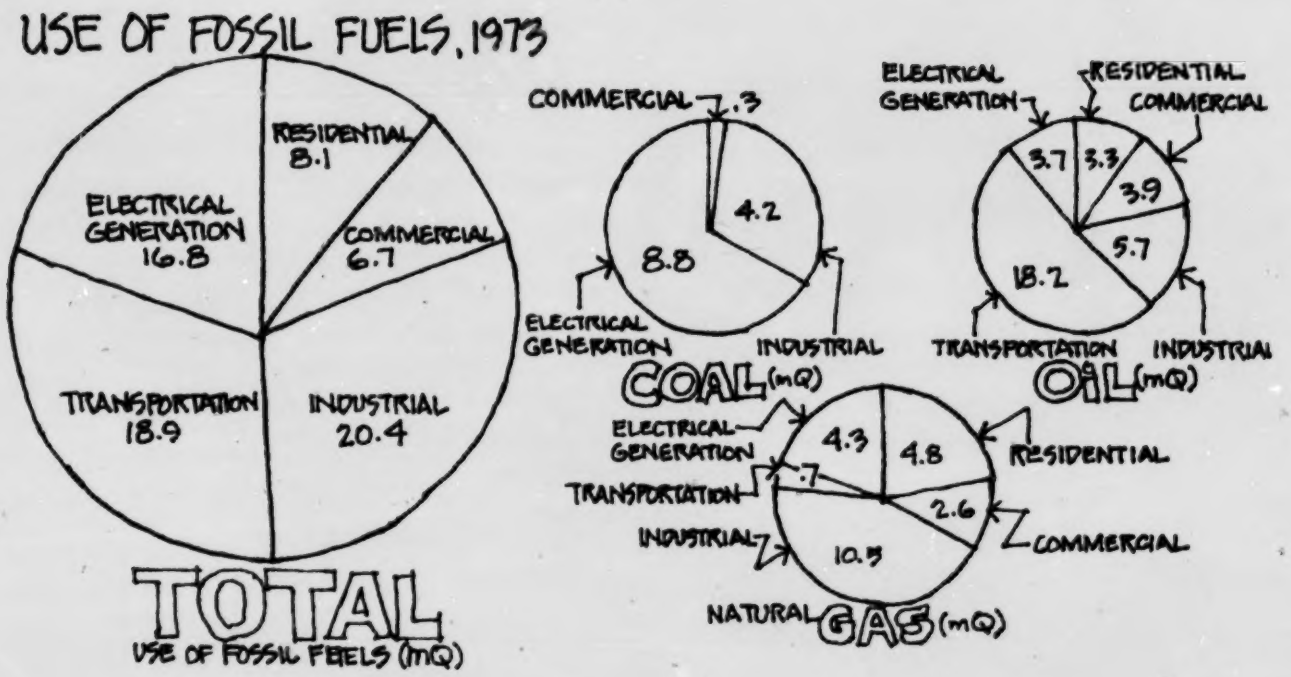
Oil

Currently 43% of our energy comes from oil. World consumption of oil has grown at an annual rate of 6.6% since 1940 and as much as 8% annually during the 1960's - at a conjectural growth rate of 5% - the world's presently recoverable oil resources would be exhausted by 2010 - that's thirty-three years. It is clear that the U. S. is looking towards an uncertain energy future with a spiralling energy demand. To maintain the world yearly consumption of 20 billion barrels of oil per year, a new Kuwait or Iran must be discovered every 3 years or another Texas or Alaska every 6 months. High rate of growth of oil consumption can not be sustained.

In most discussions of energy reserves "oil" refers to the total amount of petroleum liquids. Oil includes both crude oil as obtained from oil wells and natural gas liquids, such as propane and butane obtained in the processing of natural gas. Because 40% of the oil we consume is used in our cars, it is essential that great attention be paid to making our autos more fuel efficient. Reducing gasoline consumption by car pooling, bicycling and walking is one method each individual can use to help ease our nation's growth in oil consumption.

Natural Gas

In 1973 natural gas furnished some 30% of U. S. energy consumption, yet it constitutes only 4% of domestic conventional energy reserves. Because the price of natural gas has been regulated, the true value of this energy source has been obscured. In 1976 natural gas in the interstate market sold at well head rates that were 25% of the BTU equivalent price of imported crude oil. Most new onshore gas production has gone primarily into unregulated intrastate market. It is estimated that gas from existing reservoirs will be able to supply only 55% of the demand by the year 1985. A decline in gas production is expected despite price increases. The difference between supply and demand will have to be met in part by increased importation of liquified natural gas, LNG. For most discussions the term natural gas refers to "dry" natural gas, the amount remaining after the natural gas liquids have been removed.



Other Sources

In 1973 - 97% of our energy needs were met by the use of the three fossil fuels; coal, oil and natural gas. Two other sources provided the bulk of the remainder; hydro power and nuclear energy. In 1976, operating nuclear plants provided approximately 10% of the U. S. electrical demand or 3% of the total national energy budget.

Projections for future energy sources invariably include an accelerated input from nuclear energy. Because Uranium is a finite resource and because no technologically safe breeder reactor has yet been developed, the nuclear fission power source like fossil fuels must be considered non-renewable. Persistant toxic wastes, thermal pollution and potential terrorist acts all make nuclear power a dangerous energy source. Unlike low technology, decentralized renewable resource power generation, nuclear power stations concentrate energy production in one location. The effect of a nuclear mishap on the electric grid may be likened to the death of a mule on a 20 mule team. Decentralization and diversification of energy sources can forstall a massive brown or black out. As in nature, species diversification marks strength, so too in our search for new sources we must seek out a balance of alternatives.

Hydro Power

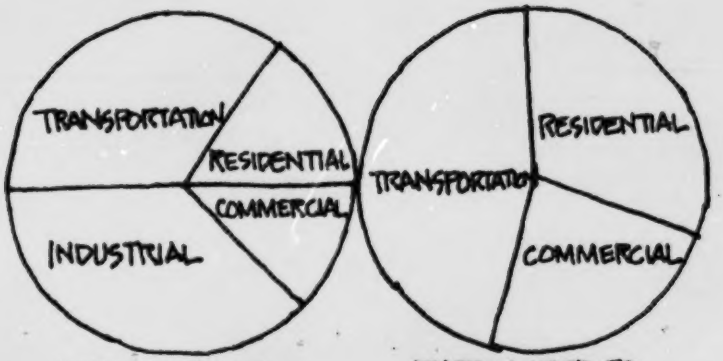
Hydro power once played a key role in energy generation in the United States. Many industrial centers sprang up at points along rivers where falls in waterways made hydro power available without massive damming. Maine owes much of its success in the textile and shoe manufacturing industries to cheap and abundant hydro power. In 1973 hydro supplied about 1.3% of our current energy budget. Because hydro generation of electricity is extremely efficient (as high as 85%) it is considered an attractive energy source. However, like all potential energy sources hydro power is now without its environmental hazards. Most of the country's best sites are now developed. Additional sites, in general, are expensive to develop, low in capacity and uncertain in energy.

Maine currently has 36 hydro-electric sites. The Army Corps of Engineers has developed 10 more sites whose cost/benefit analysis suggested further consideration. The Dickey-Lincoln is one such candidate. In short, the great expansion of hydro electric sites is improbable. However, small scale generation of electricity and the use of hydro power for mechanical energy are two realistic possibilities.

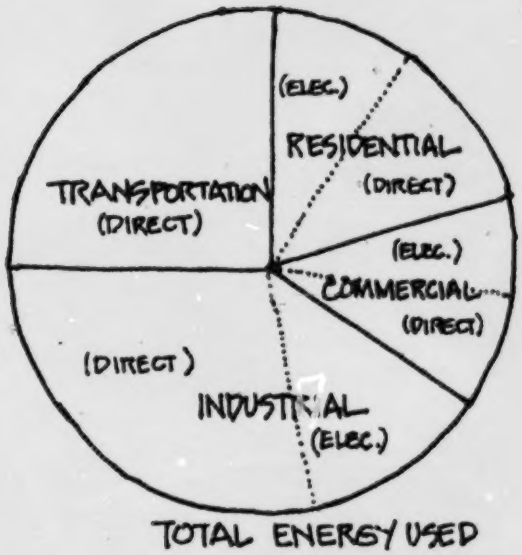
Energy Uses

An analysis of how our nation's energy is used shows areas where greatest personal effort can be made to produce the greatest energy savings. Energy use can be broken down into four basic areas:

1. Industrial
2. Transportation
3. Residential
4. Commercial



ENERGY USE BY SECTOR

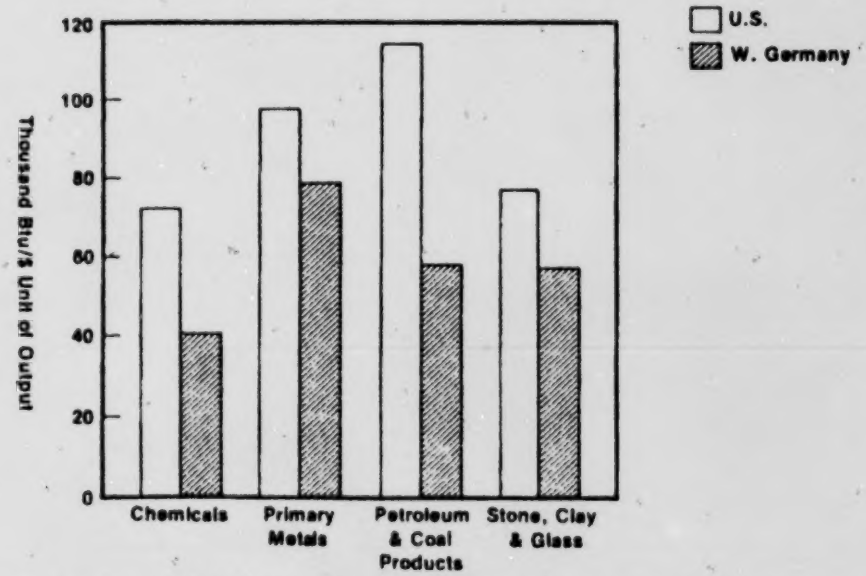


TOTAL ENERGY USED

Industrial
(39.6% of national energy budget in 1973)

To the extent that each individual can decide which products to buy, the industrial energy diet can be trimmed. Although strong economic incentives already exist to encourage industry to save energy, much improvement still can be made. The co-generation of electricity and process steam, for example can provide substantial energy savings. A comparison with West German industries suggest we can do better in the industrial sector.

U.S. Industry Energy Efficiency Compared to West Germany, for Major Energy-Intensive Industries



Source: Comparison of Energy Consumption Between W. Germany & the U.S., Stanford Research Inst., June 1975.

Transportation (26% in 1973)

Of energy expended for transportation, some 55% went for gasoline for our cars. The need for increased gasoline milage is clear. Car pooling

is also essential in order to reduce our energy consumption in this sector. It has been estimated that if 4 community cars out of 10 carried 1 additional passenger, 2.5% of total oil consumption, about 400,000 barrels per day could be saved. Decreasing the weight and power of the average automobile can also produce drastic savings.

Residential (19.1% in 1973)

In the residential sector, space heating is the big killer, using over 10% of the national energy budget. The implications for architects and owner-builders is clear-having an energy efficient house is probably the single greatest contribution the individual can make in the struggle to decrease overall demand. Hot water heating also plays a significant role in residential energy needs; 2.5% of the national energy budget is devoted to the heating of hot water. It is in precisely these two areas where solar energy can make its greatest immediate impact. Passively heated homes with solar hot water systems can help slow down our spiralling energy consumption.

Commercial (15.4% in 1973)

The commercial sector includes the energy used to heat, light and air condition stores, post offices and motels, also the energy used to run schools, hospitals and the military is included in this "miscellaneous" category.

Electricity

One significant trend has emerged over the past several decades; the demand for electricity is doubling about every 10 years. This popularity is due to the increased use of electric baseboard heat. Thermodynamically, the use of electricity to provide a low grade source of heat is foolish. Although the 6.6 mQ of electricity generated only about 10% of the total energy used in America in 1973, this electricity represented about 2 1/2 times or 25% of the energy problem. The generation and transmission of electricity is at best 33% efficient. Changes in price structuring which do now reward big users will help to curb this rapid increase in electrical consumption.

Environmental Effects

The sad truth is that pollution and environmental degradation are inescapable by-products of energy production and consumption. All energy sources have their disadvantages; however, the renewables have significantly less harmful effects. One key energy source often forgotten is conservation. It has been estimated that we waste nearly

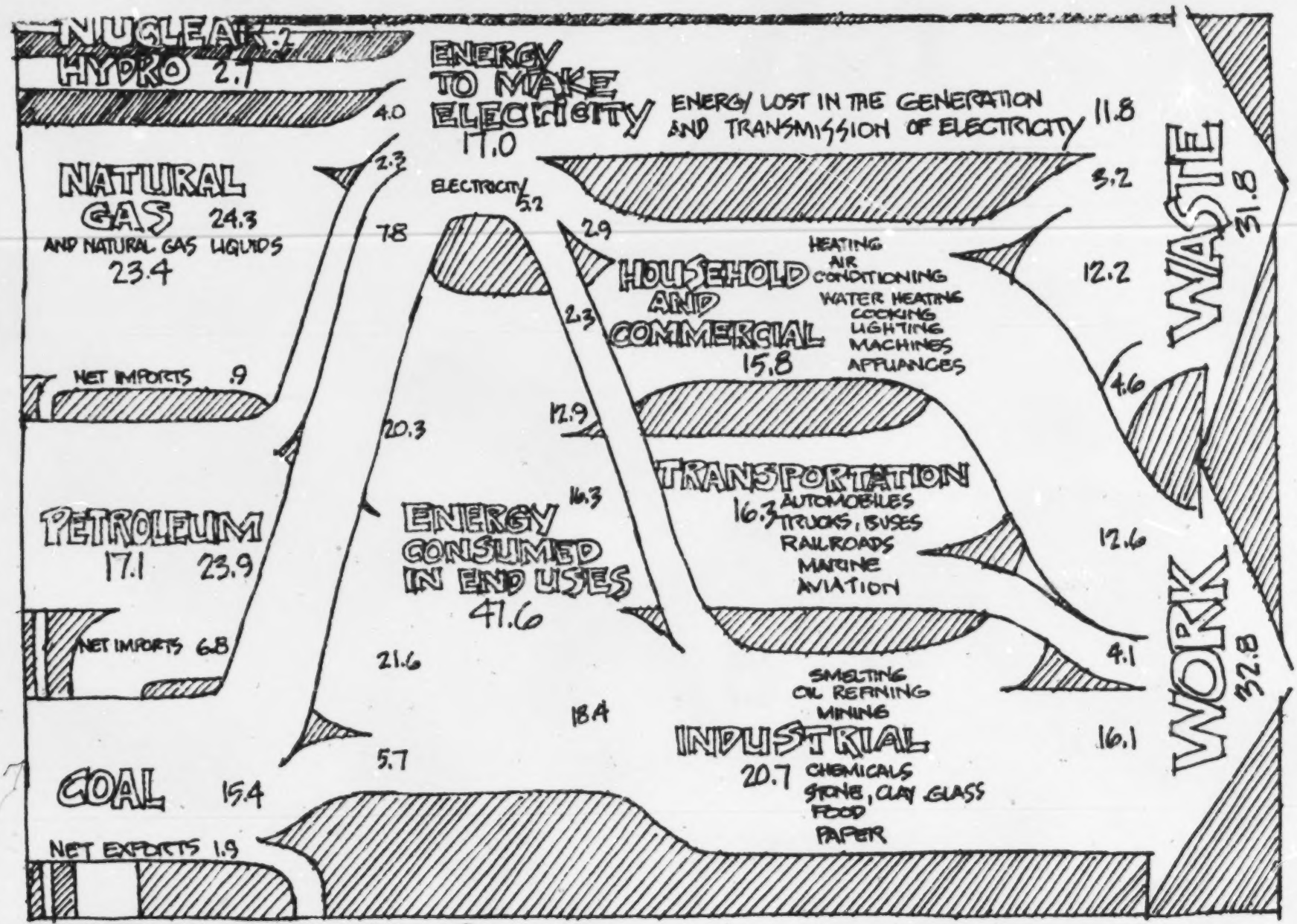
half our available energy. A conscientious program of energy conservation can lessen our energy demand in future years. Projections range from 100 - 190 mQ by the year 2000. This difference is indeed significant. The acceptance of the need for energy efficiency in all phases of our national economy can lessen or halt the need for expanded energy sources.

Personal Life Style

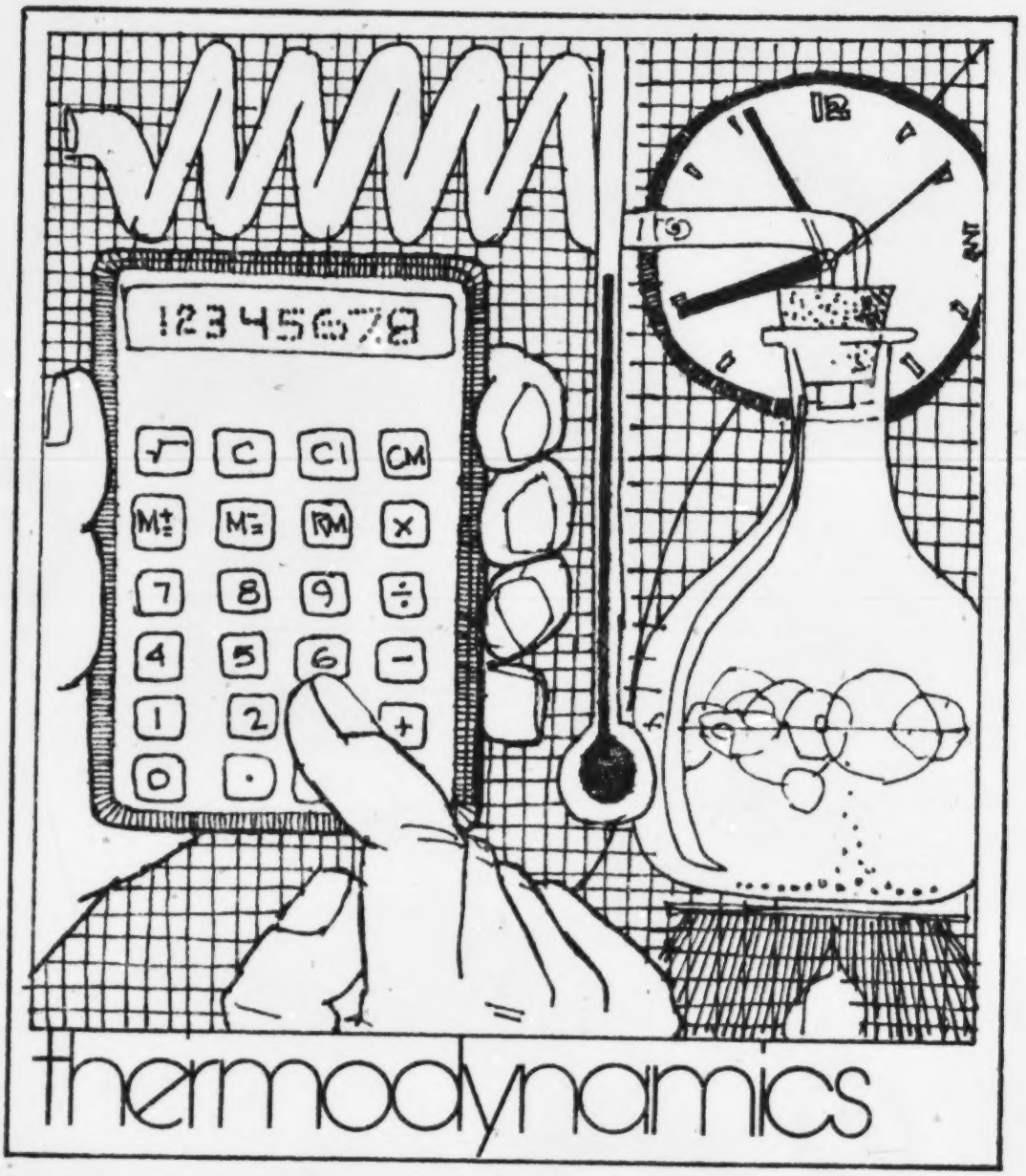
The question is often asked, "What can I personally do to help solve the Energy Crisis?" A careful audit of personal consumption in all sectors is an important first step. Several significant contributions can be made by;

1. Thermally upgrading the family home or apartment
2. Improving the efficiency of the furnace and all appliances
3. Keeping the family car tuned up or even trading in a gas guzzler
4. Car pooling or using mass transit
5. Growing your own food
6. Switching to less energy consumptive recreational pastimes e.g., try jogging, bird watching, cross country skiing, etc.

The chief goal in studying traditional energy sources is to help each individual see where the energy comes from and how it is used. This understanding can help each of us reorient our lives to be less energy consumptive. The demystification of traditional as well as alternate energy sources is that first key step towards creating a public energy awareness.



U.S. ENERGY FLOW — WHERE IT COMES FROM... WHERE IT GOES. (EXPRESSED IN 10^{15} B.T.U.'S)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THERMODYNAMICS

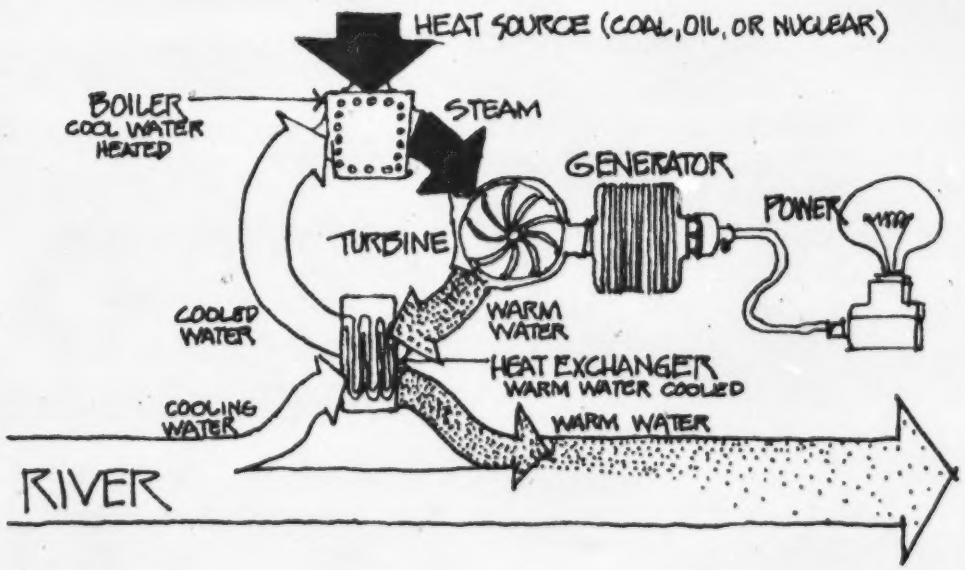
INTRODUCTION

Understanding basic thermodynamics is a prerequisite for understanding today's energy crisis. Many of the key concepts in thermodynamics were formulated in the mid-19th century. The pioneering research done by James P. Joule, Nicholas Carnot, Count Rumford and others laid the groundwork for today's science.

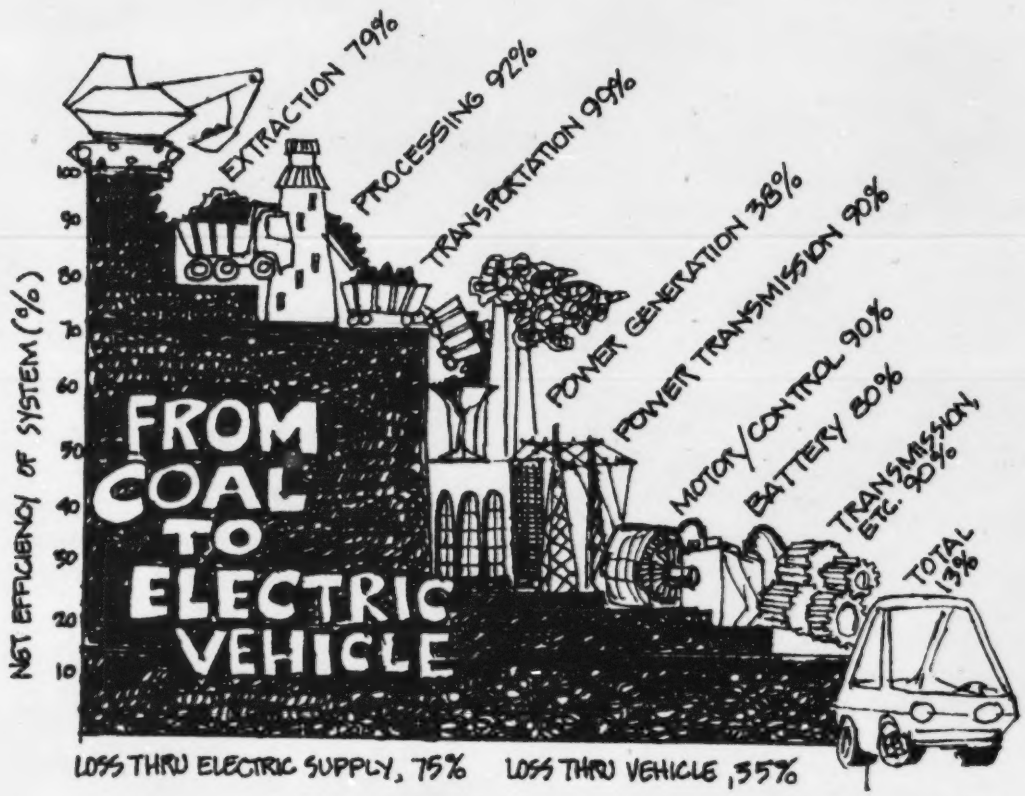
Thermodynamics is that branch of physics which deals with the mechanical action or relations of heat. A review of some of the basic laws points out the thermodynamic folly of many of our energy delivery systems. According to many of todays scientists ours is not an"energy crisis" but an "entropy crisis". The laws of thermodynamics help us understand this key difference.

Energy Forms

Energy exists in a variety of forms; some of which are; gravitational potential, electrical, chemical, nuclear and thermal energies. These forms of energy can be transformed from one to another, although at great expense. Most conventional electrical generating plants utilize some heat source to drive a turbine which generates electricity.



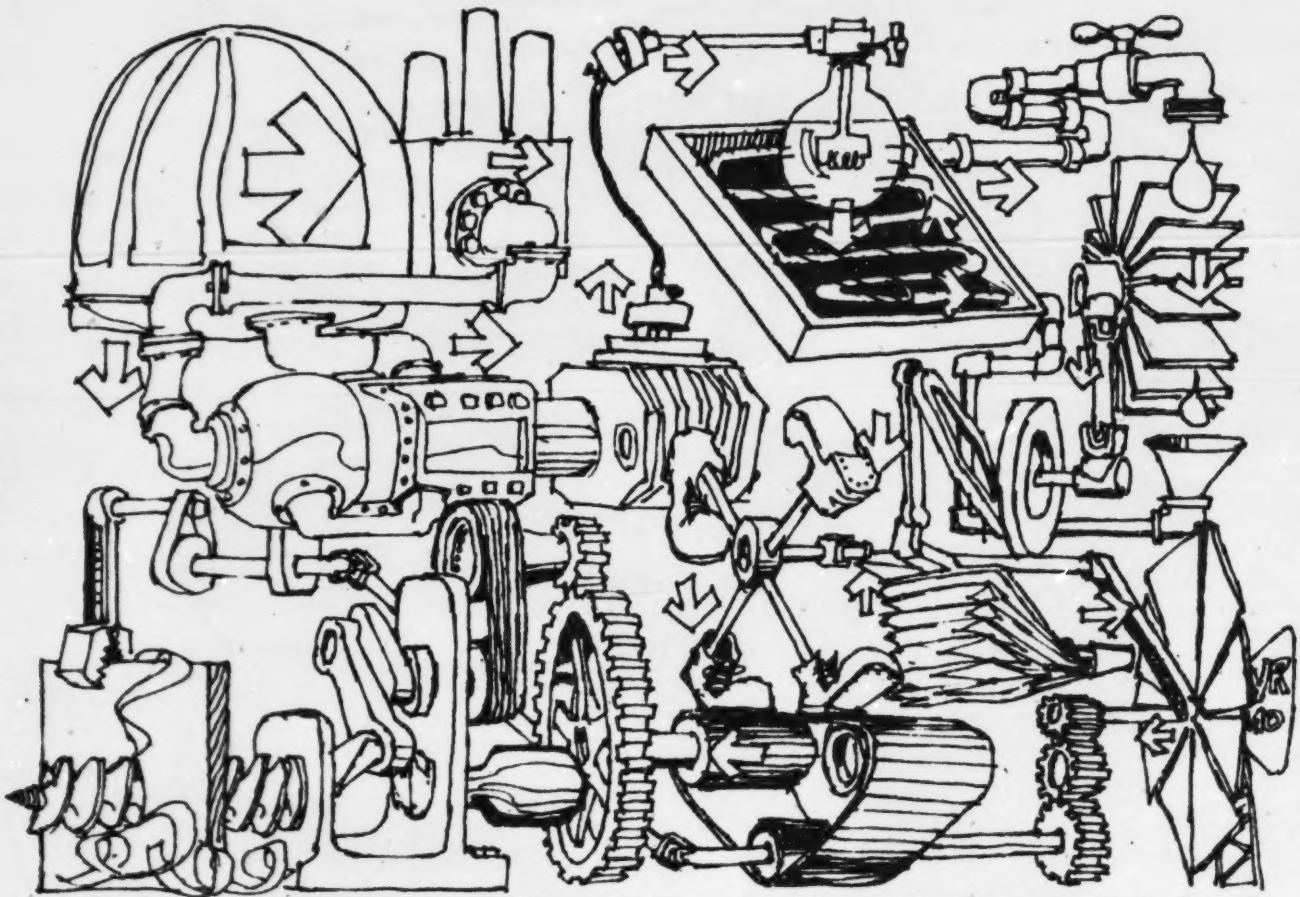
Hydro electric power uses the gravitational potential energy of falling water to mechanically turn generators to produce electricity. Wind electric systems also rely on the conversion of kinetic to electrical energy. Converting energy to more useful forms is an inherently wasteful process.



Of all the forms of energy, electricity is the most versatile; it can be easily stored, transported and most importantly, it can be used to accomplish a wide variety of tasks. In short, it is a high grade form of energy. Heat on the other hand, is a less useful form of energy. All forms of energy tend to "degrade" to heat - (thermal energy) as they are transformed down the energy ladder. Although different forms of energy can be used to accomplish any one specific

task, it is essential that a thermodynamic match be made between the energy source and the task at hand.

For example, suppose we wanted to bore a hole through a piece of wood. We could light a fire to heat up an ice pick to burn our way through the wood or we could drop a cutting die with a razor sharp edge from a large height. Another option would be to use an electric drill with a bit.



HOW TO DRILL WOOD WITH NUCLEAR ENERGY... OR, THE MEANING OF POWER TRANSMISSION LOSS

The most efficient way to utilize energy is to match the source with the task. Use of a hand drill probably makes the most sense. Again remember that every time energy is converted from one form to another, heat

is liberated; the energy is degraded to a less useful form.

Energy and Power

Energy is a difficult concept to define simply. To understand energy we must go beyond the dictionary definition: the ability to do work. In strict terms not all energy can be used to do work; some concentrations of thermal energy (for example) are so minute we have no practical way to effectively utilize that energy. The price may be too costly to perform work, but the thermal energy or heat is still there.

We can learn what energy is and how it operates by further experimentation. These lessons are more useful than deciding upon a strict definition. However, several key points need to be made; 1)energy comes in various forms, 2)energy can be converted from one form to another, 3)all energy must come from some source at some price and 4)all energy degrades to heat. Power is simply the rate (per unit time) at which energy is available or used.

Heat vs. Temperature

All too often the words heat and temperature are used synonymously. Thermodynamically, the concepts are quite different. Temperature is a measure of the amount of thermal energy a substance possesses. Thermal energy is an internal energy, that is; it relates to the amount of disorderly kinetic energy that exists on a microscopic level. The greater the excitation of the individual molecules, the higher the temperature of that substance will be.

Heat flow on the other hand is the process of transferring thermal energy. Heat is energy in transit. Since it is impossible to possess heat, we can not, say for example, that an outdoor tub has a lot of heat. It may contain water of high temperature, water that therefore possesses large amounts of thermal energy, but it does not have high heat.

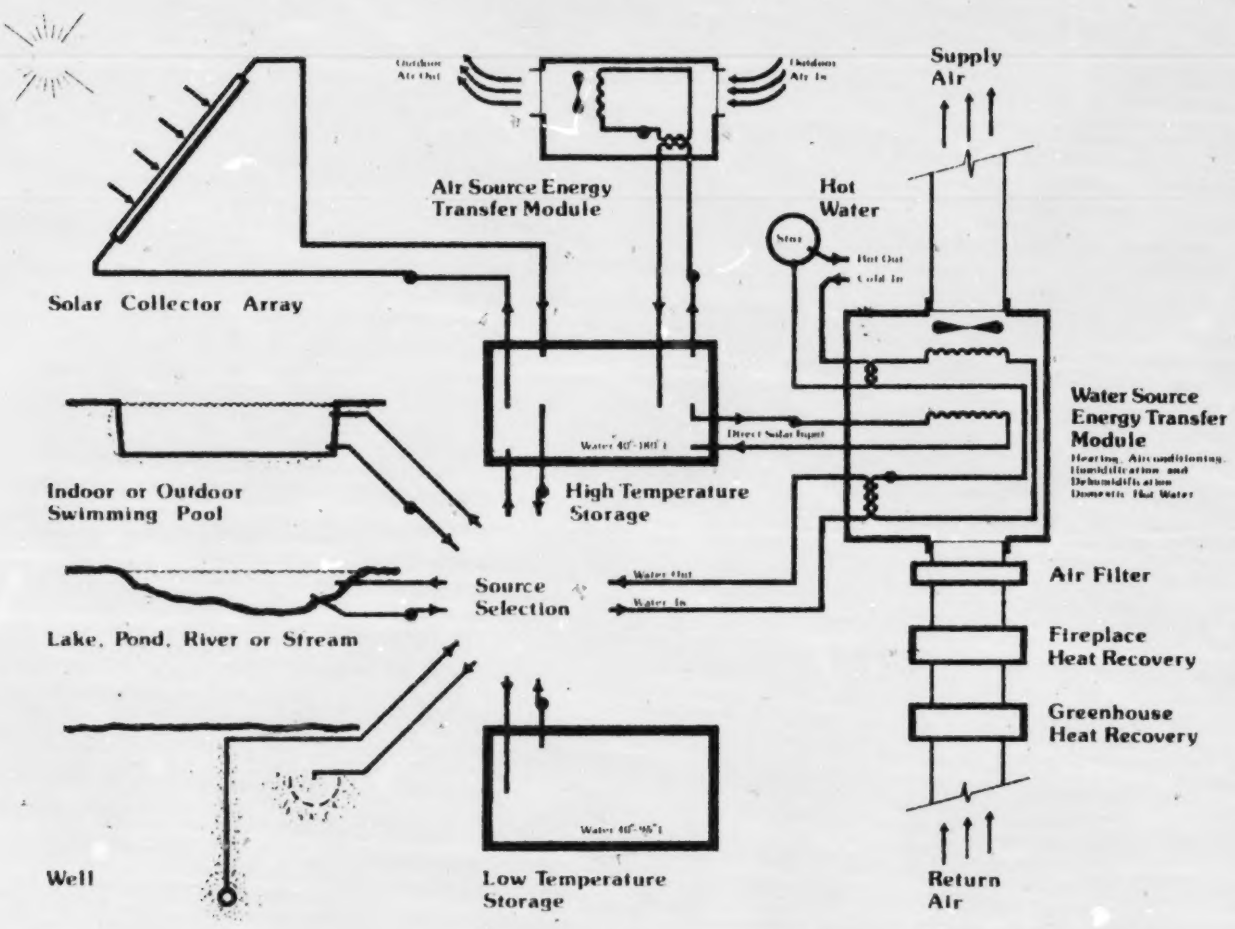
Take for example two tea pots of water placed on electric stove burners of exactly equal size. One tea pot is filled with 500 ml. of water, the other with 1,000 ml. (1 liter). If each burner is turned to high heat for an equal amount of time (6 minutes) an equal amount of electrical energy is transformed to heat on each burner. After 6 minutes, the temperature of the water in each tea pot can be measured. Obviously, the teapot containing less water will be of higher temperature. The energy transfer or heat flow was exactly equal, yet the water temperatures in the two pots differ.

The thermal energy of a substance can be increased in two manners; 1) by a flow of heat or 2) by the performance of work. When we pound a nail into a board, we have performed work. The extraction of that nail

will show it to be hot. Likewise, if we were to burn that block of wood the nail would further increase in temperature because of heat flow from the surrounding burning matter.

Work + Heat ⟶ Change in Temperature

This distinction between heat and temperature is made apparent in the operation of certain heat pump systems. These units can extract useful heat from sources of relatively low temperature. For example, there is a house in Rhode Island that gets all its heating, cooling and hot water from the thermal energy extracted from well water of about 45°F. Its water seems too low in temperature to be of any great use, but because of the investment of electrical energy in the heat pump, the thermal energy of the water can be extracted.



ENERGY SYSTEM SCHEMATIC

Reprinted with permission from Steven J. Strong, The Natural House

1st Law of Thermodynamics - The Accountant's Law

This first fundamental law tells us that in a closed system the total amount of energy remains constant. Energy can neither be created nor destroyed. If this fundamental law holds true, "Why then is there an energy crisis?" people ask.

We know that energy can be converted from one form to another, some forms are more useful than others. When we burn a piece of firewood the reaction liberates heat, a variety of gases, smoke, tars and ashes. The total energy or caloric content of the wood is dissipated forever as combustion takes place. It is not destroyed but merely parcelled out in less or unusable forms. The first law tells us that all energy can be accounted for; it is neither created nor destroyed, just transformed.

2nd Law of Thermodynamics - Humpty Dumpty's Law

This law states that the universe is constantly becoming less ordered. Entropy is a measure of the amount of disorder in the universe, a measure of the unavailability of energy for work. Just as all the king's men couldn't put Humpty Dumpty back together again, so too does the burned piece of wood represent an energy concentration impossible to reconstruct from the available wood. The total potential energy available from the wood is forever released upon combustion.

This 2nd law teaches us that all forms of energy ultimately degrade to less usable forms. Where as it is easy to convert chemical energy to thermal energy, reversing that process is extremely difficult.

Except for specific growth patterns of individual organisms, all systems tend towards greater disorder. A teenager's bedroom will often tend towards chaos, unless conscientious efforts are made to keep it straightened up. The breaking of a pool rack sends the fifteen balls off in all directions, into an array of much greater disorder.

To suggest that our country's "Energy Crisis" is more an "Entropy Crisis" is to show a basic understanding of thermodynamics. Ample energy is available to us on planet Earth. A recent Ford Foundation study concludes;

"The amount of solar energy falling on the U. S. is enormous; 44,000 quads per year. The present annual U. S. consumption of electrical energy could be supplied by 0.15% of this solar energy, if it could be used at 10% efficiency"

We are developing nuclear technologies that offer potentially unlimited energy, although at great environmental risk. Some estimates show us to have centuries of coal remaining to be mined.

What is always overlooked in these projections is the thermodynamic reality that the more energy we use (i.e. convert from one form to another) the more waste heat or thermal pollution is created as the energy systems tend towards greater entropy. It is a scientifically accepted fact that the average global temperature is increasing, largely as a result of the impact of man on his environment. The long range effects of these climatic changes are little known. If we continue to double our electrical consumption every ten years, within less than 200 years every square centimeter of land in the U. S. will have to be devoted to energy production. Clearly this is an absurd and impossible projection. The so-called energy crisis may in fact be more a problem of putting the breaks on the consumptive patterns of the past, than finding new sources of energy. The energy joy ride is over.

Net Energy

Often times statistics are presented which show vast untapped energy resources. Yet one key concept is often overlooked: net energy. It takes energy to get energy. As the highly concentrated, easily obtained natural resources are depleted, we will need to expend more and more energy to retrieve fewer and fewer resources.

At some point a careful analysis of total accounting must be made of every project before it is undertaken. Consider the case of the lumberjack who sits in the freezing cold, huddled around a cabin stove. With no more logs to burn, he is faced with the key question; Should he go outside to the log pile or will his opening the door lose more heat than he can expect to gain from a new fire?

Numerous new projects demand this type of net energy survey. Will the Alaskan pipeline supply enough oil to make its building worthwhile? Is liquification of coal thermodynamically sound, if by the time the fuel has been produced, 1/3 of the coal's original energy content has been used to run the liquification process? Is nuclear power cost effective if 1/2 the electrical output has to be recycled to supply input for fuel processing.

Thermodynamics and Hot Water Heating

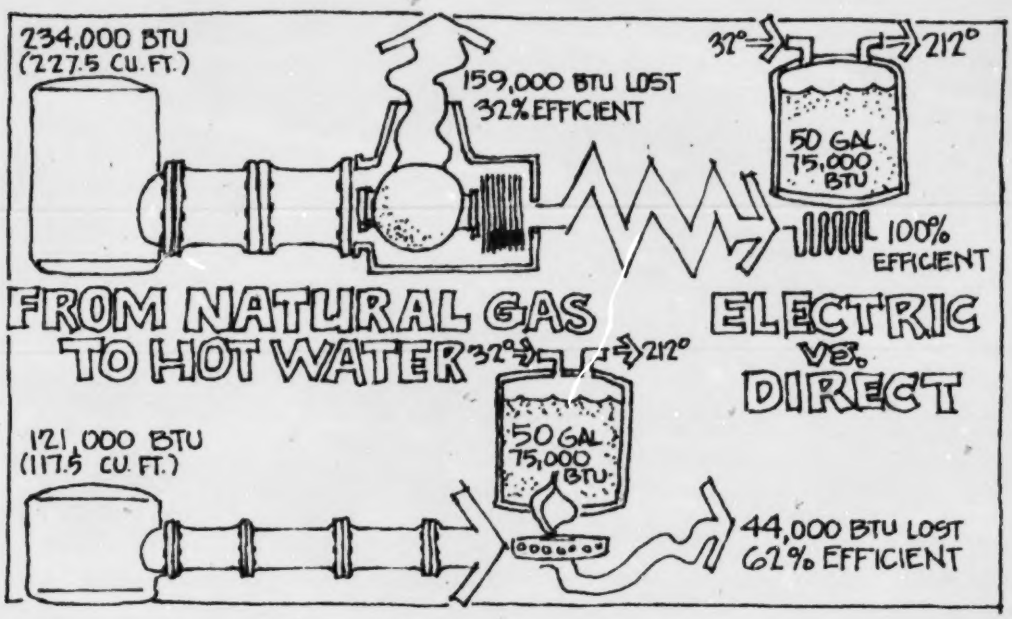
The laws of thermodynamics tell us that energy is lost at each

step of energy conversion. Consider the example of using natural gas to heat hot water. The end result in both cases is to supply 75,000 BTU to 50 gallons of water. We can choose either of two paths:

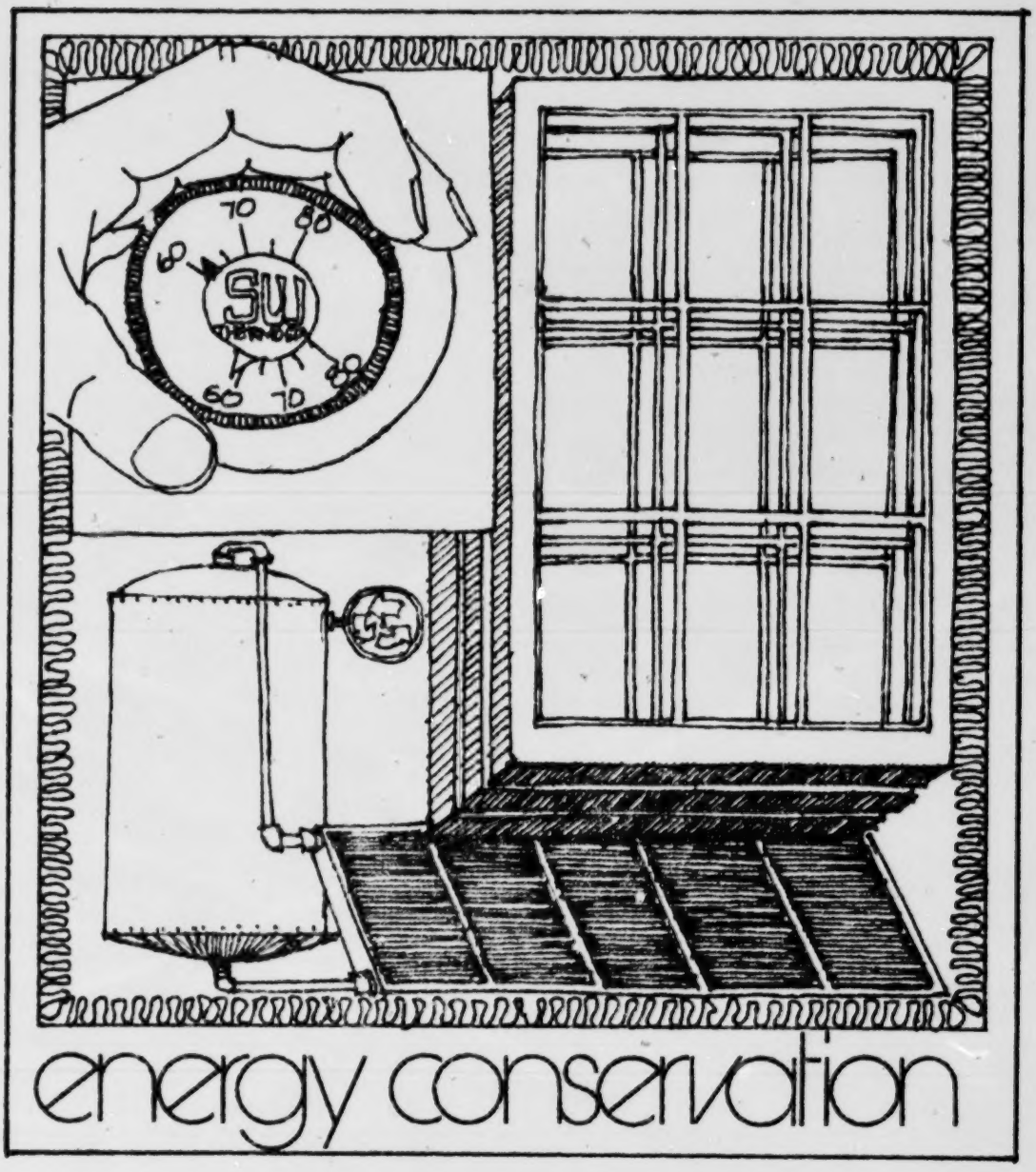
A. Convert the natural gas to electricity which in turn is an electric resistance heater in the hot water tank

or

B. Use the natural gas to heat the water directly



In order to achieve the same end result, path A requires 234,000 BTU as opposed to path B which requires only 121,000 BTU; a saving of almost 50%. Although the conversion from electricity to heat is nearly 100% efficient as compared to a 62% efficiency in direct combustion, total energy used by using fewer energy conversion steps is substantially less. Shortening this chain from energy source to energy task is of paramount importance.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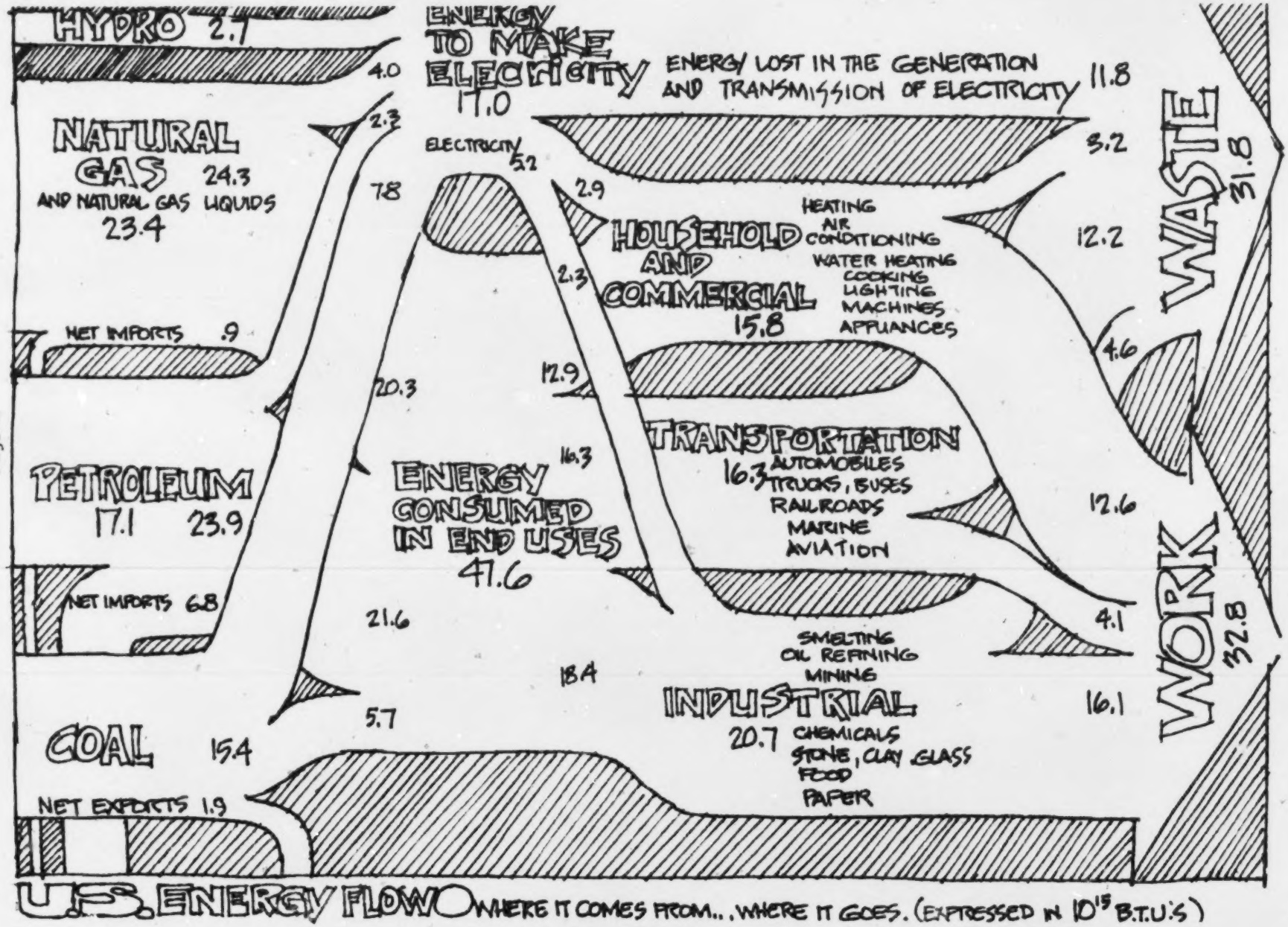
INTRODUCTION

In April 1977 President Carter exhorted Americans to embark upon a crusade, "the moral equivalent of war," in search of solutions to our nation's energy problems. Energy conservation and coal development are the two cornerstones of the National Energy Plan. The President explained that each American would be called upon to make some sacrifices. What are those sacrifices? How painful, or perhaps healthy, might these changes be?

Most Americans think that a massive national program for energy conservation means a return to a primitive, uncomfortable way of life. Images of dark, dank underground houses, kerosene lamps flickering dimly, and meatless meals pop into people's minds. Where can the most significant and least unsettling sacrifices be made? How significant are many small individual changes in light of the total national energy budget?

TRIMMING THE FAT

It is essential that all Americans realize that the U. S. economy presents many opportunities for energy conservation. As the work/waste graph demonstrates, we waste nearly as much energy as we convert to useful work.[1] A sector-by-sector analysis suggests that each of us can cut down in many areas of our daily lives. This type of personal review will lead to a greater citizen awareness and more involved public input into governmental policy decisions.



U.S. ENERGY FLOW WHERE IT COMES FROM... WHERE IT GOES. (EXPRESSED IN 10^{15} B.T.U.'S)

Page 2

In trimming the fat off the national energy budget, it is essential that we don't cut off an arm or a leg as well. Instead, we need to review the workings of the entire organism and then begin a systematic change of those areas with the greatest potential for revitalization.

Consider these facts:[2]

.....In 1975 the United States wasted more fossil fuel than two-thirds of the world's population uses every year.

.....Americans consume more energy per capita than any other country, about 100 times more than the citizens of the least developed countries.

.....In the years 1960-73 the United States growth in fuel consumption increased on the average 4.1% per year, a doubling time of about 17 years.

.....In the last 25 years, world fuel consumption tripled; oil and gas consumption quintupled; and electricity consumption was up sevenfold.

There exists growing worldwide resentment against Americans who continue to exploit a disproportionate share of the world's non-renewable fuel and mineral resources. As more countries industrialize, foolishly ignoring many of America's mistakes, the strain on these non-renewable resources will become intense.

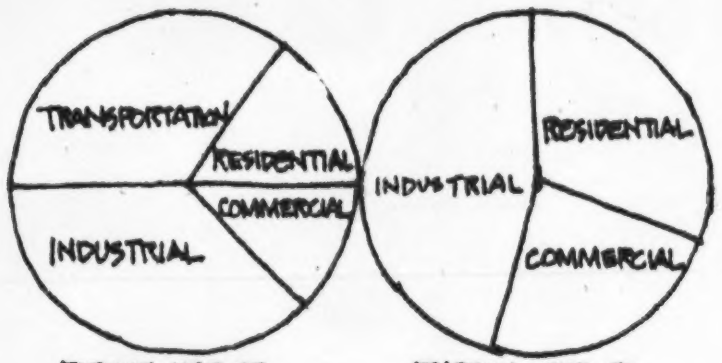
A switch to an energy conserving ethic will not be easy. A host of institutional barriers works against this transition, e.g. mass marketing of short-lived consumer articles, artifically low energy prices, and utility rate structures which encourage waste.

Two compelling arguments can be made for the adoption of an energy conservation ethic:

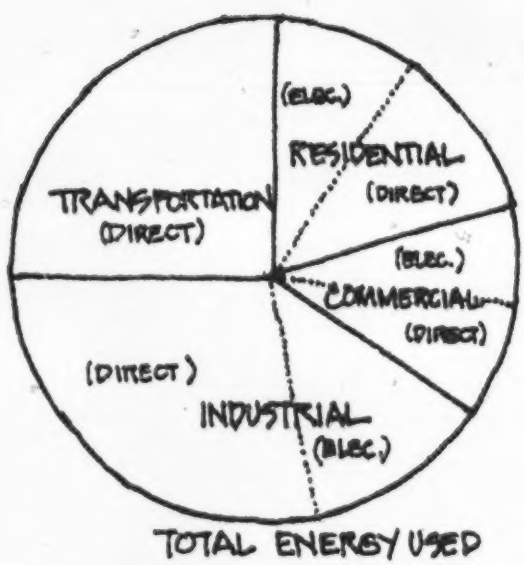
(1) It is morally wrong for Americans to consume a disproportionate share of the world's wealth.

(2) Thoughtless exploitation of the soon-to-be-scarce non-renewable fuel and mineral resources will not provide us with the flexibility to plan and implement new production technologies.

A strict breakdown of the national energy budget into its four sections reveals only a portion of the total energy-use picture.



ENERGY USE BY SECTOR.



TOTAL ENERGY USED

Many people feel that their personal impact is limited only to the residential sector. Not so. Each person must decide what type of products to buy, what food to eat, what sort of transportation to use, and which type of dwelling to live in. In a sense then, consumer tastes can dictate energy conservation in all sectors. An intelligent use of electricity can affect consumption in each area.

Consider these facts:[3]

.....42% of all energy in America is used in the transportation sector; of that, 24% is used in direct fuel consumption; 18% is used to build and maintain vehicles and roads.

.....In America today there are more licensed drivers than registered voters.

.....There are two cars produced for every baby born.

.....Motor vehicle and allied industries account for about 1/6 of the GNP and about one out of every six jobs.

.....56% of all commuters drive to work alone.

.....Abandoning automatic transmissions could cut fuel consumption by 10%.

.....Trucks haul less than 1/5 of all freight yet use about 1/2 of all fuel.

In short, American transportation systems are tremendously wasteful. More and more energy and resources are going into less efficient modes of transport. Here is an area where massive savings can be made. The following list of suggestions points out many opportunities.

(1) Support and use mass transit. The urban automobile, as currently used, consumes 2.24 times more energy per passenger mile than does a bus.[4]

(2) If you purchase a new car, buy one with top gas mileage. There are now available American-made automobiles which register twice the fuel economy of the average car.

(3) Equipping your car with radial tires can result in a 10% reduction in fuel consumption.[5]

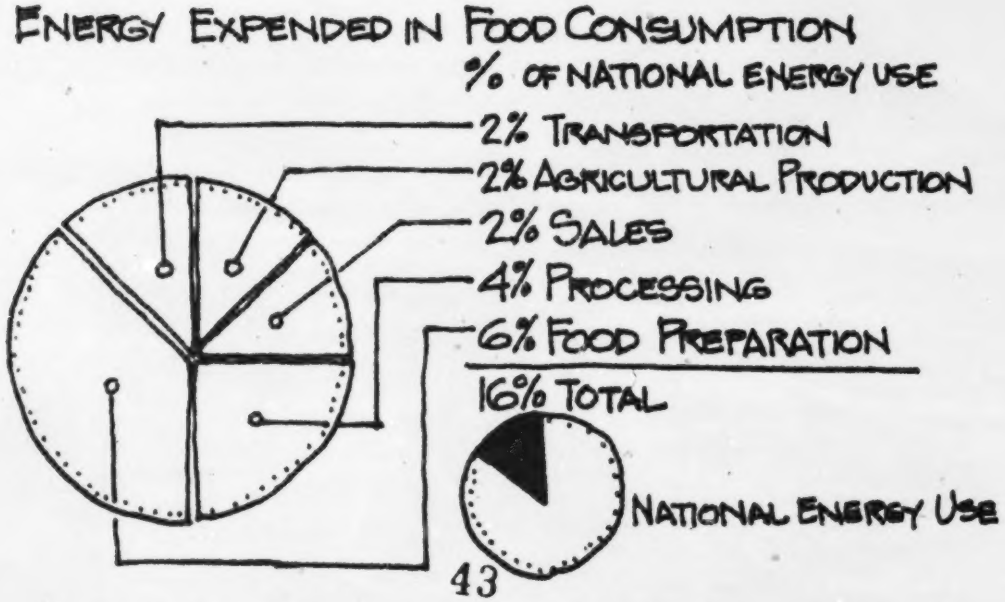
(4) Keep your old car on the road as long as possible. Replacing worn car parts can triple the life expectancy of the average vehicle for an energy cost of only about 15% of that of a new automobile.[6]

(5) For short trips, use alternate forms of transportation (e.g. bicycle -- or walk) as much as possible. Car pool to cut down on passenger mile fuel consumption; plan trips to include as many errands as possible per trip.

ENERGY, FOOD AND YOU

Perhaps in no other sector of social activity will Americans resist change more fervently than in the area of food. Eating is either an inescapable burden or a luxury of life. The production, distribution, and consumption of food uses about 16% of the national energy budget. Because the food production system requires energy inputs from all economic sectors, it is sometimes given little scrutiny.

Substantial savings can be made in this most essential life support area. The food and energy graph is represented below:



A close look at the graph reveals several interesting facts:[7]

.....We spend about 6% of the national energy budget in the processing of food. The movement towards more natural, less-processed foods makes energy sense as well as nutritional sense.

.....Eating lower on the food chain also incurs less drain on our energy sources. For example, it takes about six times more energy to produce one pound of feedlot beef protein than one pound of chicken protein.

.....A small garden eight meters square has the potential of reducing each family's energy requirements in the food area by 1/3. Energy-wise processing and storage can further reduce consumption.

Some specific suggestions follow:[8]

.....Increase home gardening and fruit growing.

.....Shift to vegetable from animal protein.

.....Reduce use of over-processed foods, especially frozen specialities.

.....Avoid non-returnable beverage containers.

.....Increase the purchase of bulk and unpackaged foods.

SPACE HEATING

Heat energy in a house is very much like water in a leaky bucket. Think of it this way: the bucket is the house; the holes in the bucket are the ways in which heat leaks from the house; the water is heat energy; the level of the water is the temperature of the house minus outdoor temperature.

In the case of the bucket, in maintaining a certain water level, the rate at which we must add water is proportional to the number and size of the holes. Also, the higher the level of water we try to maintain, the faster we must add water. Using the bucket analogy, we can see that the amount of fuel we burn to maintain a certain house temperature is proportional to the number and size of the heat leaks. The amount of fuel is also increased as we increase the house temperatures. There are two sorts of heat leaks in a house: 1) conduction through the skin of the building, and 2) actual leakage of warm air through holes (infiltration).

Let's look first at conduction through the skin. Heat leaks through every external surface of a house including the floor or basement. Therefore, we should look at the roof, walls, basement walls, basement floor (ground floor if the house has no basement), doors and windows. The rate at which heat escapes from each of these surfaces is inversely proportional to the thermal resistance (R) of the surface. Table 1 shows the R values for the surfaces of houses as they used to be built (you may live in one of these houses). The right side of the table shows how the R value of each surface could be increased.

Table #1

Old House Surface		R	New or Retrofitted House
Roof	=	3	insulate with 12" fiberglas, R = 41
Wall	=	4	insulate with 4" blown insulation, R = 16
Basement	=	10	insulate walls with 3 1/2" fiberglas or 2" styrofoam, R = 20
Ground floor	=	5	insulate with 6" fiberglas, R = 25
Door	=	2.5	add storm door, R = 4; substitute insulated door, R = 10
Window	=	1	add storm window, R = 2; add insulating shutters, R = 10

You can see that an older house can be retrofitted, or a new house built, to leak only 20% as much heat through its surfaces as an uninsulated house!

How let's look at the other sort of leak, the real physical leakage of air through cracks and holes. Prowl around your own house. Hold a match up to suspicious areas (exercising necessary care). If the flame flickers, air is leaking through that hole. See how good a detective you are. In case you overlooked them, check these:

a) around doors

b) around windows

c) through electrical outlets

d) through holes in the foundation or between the top of the foundation and the woodsills

e) through dryer vent (is the inside of the dryer colder than the rest of the room?)

f) through kitchen and bathroom ventilators

g) up the fireplace

h) through the automatic damper on the furnace flue pipe

i) through the door when someone goes in or out

All of these holes can be plugged. Leaks (a) through (d) can be caulked with a caulking gun just as if the house were a boat. Leak (e) can be eliminated by venting an electric dryer indoors. Put a pillow case or nylon stocking over the vent with a rubber band to catch the lint. Leak (f) can be reduced by not using the vent any longer than necessary. If the fireplace, leak (g), is not used in the winter, make sure the damper is closed completely. If this is impossible due to a broken or poorly fitting damper, stuff the flue with wadded newspaper. If the fireplace is used in the winter (not a very efficient use of wood!), glass fireplace doors are available which can be closed at bedtime; reducing the air lost up the open damper by 50-75%. It has been discovered that, while a new furnace (leak (h)), may be 80% efficient <u>while running</u>, it may average less than 50% efficiency because of warm air being drawn up the flue pipe the remaining time. Fuel consumption can be reduced from 20 to 30% by the installation of a furnace damper which closes fully when the furnace is not running or by reducing the firing rate and the flue pipe diameter. Talk to your oil burner repairman about these possibilities. Leak (i) can be eliminated if an air-lock entrance is installed similar to the air locks on submarines. If this is impossible, get in and out of the door quickly!

Do you remember how the amount of heat lost is proportional to the temperature inside the house minus the outside temperature? To put a number on it, fuel consumption drops by 3% for each F° reduction in the thermostat.

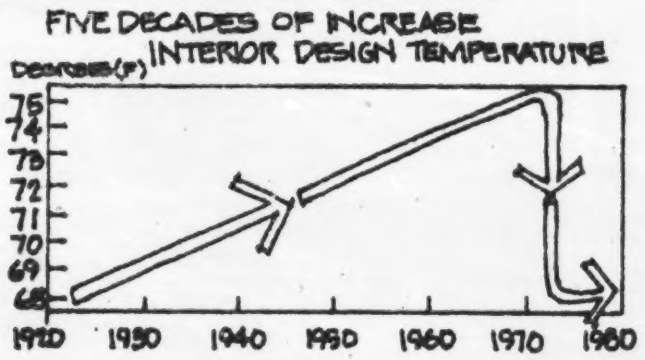


Figure #1 shows how cheap fuel and Americans' preferences for light clothing pushed the average indoor thermostat temperature up from 70°F. over five decades. The sudden drop to 68° F. resulted when the Arabs cut off our oil supply. Some people are now running their houses at 60°F., thereby reducing their fuel bill by 30% over that of a 70°F. home.

Our bodies can become acclimated to lower temperatures over a period of time: if you now run your house at 75°F. and were to run it at 60°F. for a month (wearing a sweater of course), returning the thermostat suddenly to 75°F. would give you an unpleasant overheated sensation. People who heat with wood stoves find living with lower average temperatures easy because they can always get warmer by sitting closer to the stove. If your house is heated in more than one zone (more than one thermostat), you can reduce the temperature (and heat loss) in unused or sleeping areas. Designers of houses should recognize this possibility and zone the heating system according to the activities in each living area.

WATER HEATING

Heating water consumes about 15% of the total energy used in the house. The typical family of four uses either 300 gallons of oil or 7,500 kWh of electricity to do this each year. We can reduce our energy consumption for hot water in three ways.

A. Use less hot water.

1) Take short showers instead of baths. The average shower consumes only 1/2 as much water as does the average bath. Check this fact by closing the drain while showering and measuring the depth of water at the end. See how little water you can use while taking a shower.

2) Install water saving spouts in showers and sinks. These fixtures consume hot water only 1/2 as fast as conventional fixtures do.

3) Leave the warm water in the tub (close the drain while showering) until it falls to room temperature. The heat lost by the water is gained by the house.

4) Rinse dishes with cold water. If you do rinse with hot water, do it all at once at the end. Don't ever leave the hot water running.

5) Fix dripping faucets immediately. One dripping hot water faucet can consume 5-10% of the total water used, without any benefit to you.

6) Wash clothes with cold water. Most detergents work equally well in cold or hot water. Clothes washed in cold water last longer.

B. Heat water more efficiently.

1) In a new house, locate the water heater closest to the major water consumers, the kitchen sink and the bath tub. On long runs, insulate the hot water pipe. A gallon of hot water may be wasted every time you use a fixture very remote from the hot water heater.

2) Insulate your hot water tank by wrapping 3 1/2" of fiberglass around it. Better insulated hot water tanks can now be purchased.

3) If your home is heated with wood and your hot water with electricity, it will pay to install a holding tank before the hot water heater. The holding tank will warm the incoming water from 40-45°F. to room temperature, reducing the load on the electric heater. Locating the holding tank close to a wood stove will heat the water even more.

4) Lower the thermostat setting on the water heater. A 10°F. drop reduces the heating cost by 3-10%.

5) If your hot water is produced inside an oil furnace, it would pay to install a separate oil water heater for summer use. Otherwise, the furnace must run all summer in order to be ready to produce hot water at your command.

C. Use alternative sources of energy.

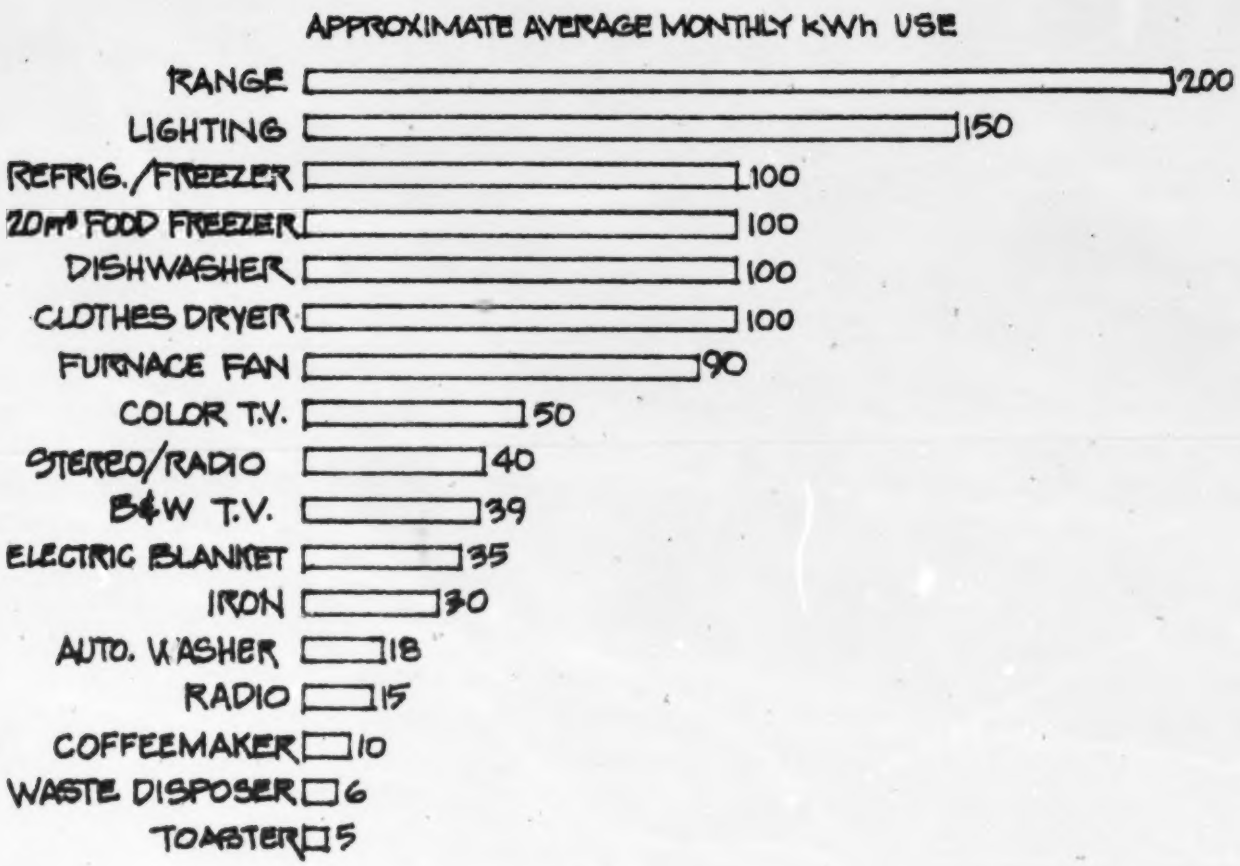
1) Already on the market are solar water heaters which can produce 50-95% of your hot water needs (depending on the season). These units preheat the water for conventional water heaters so you can have hot water even on a cloudy day. In the next few years, large companies will be selling these units just as they now sell regular water heaters.

2) If you are considering wood heat, watch for wood stoves and furnaces with built-in water heaters. Some are already available.

Table #2 shows the average number of kWh used each month by appliances and lighting. KWh stands for killowatt-hours or 1000 watts x 1 hour. You can see from the table that eliminating the toaster or an electric can opener may be effective as a philosophical statement, but it doesn't do much to the national energy budget. Let's see if we can trim down the big energy hogs on the list.

APPLICANCES AND LIGHTING

Table #2



1) Range. The efficiency of an electric range depends on the size and type of cooking pan. Make sure the pan completely covers the coil or the heat from the outside of the coil will escape. On the new smooth-type burners, use only glass-ceramic pans. Using an aluminum pan on a smooth top range will reduce the efficiency from 75% to 36%!

Utilize the oven efficiently. Do the week's baking in short intensive bursts. Keep the oven full; it takes no more energy. Cook with lids on the pots. It takes less than 1/2 as much energy and doesn't smell up the house, thereby requiring ventilation. Don't let a self-cleaning range turn you into a sloppy oven user. It takes lots of energy to clean the oven electrically.

2) Lighting. Incandescent light bulbs are only about 3% efficient in producing light. That is, 97% of the electricity is directly turned into heat! Electric heat is the most expensive and energy inefficient of all resources. Fluorescent lights are 2-3 times as efficient in producing light as are incandescent bulbs. Light bulb manufacturers are now required to label bulb packages with light output in lumens. Lumens per watt is, therefore, a measure of efficiency. You'll find that lumens per watt increased with wattage, so it's better to use one 100-watt bulb than two 50-watt bulbs. Concentrate your light sources where they are needed. There is no reason to light the entire room while you are reading a book.

3) Refrigerator and Freezer. For years, manufacturers have promoted the "thin-wall" refrigerator and freezer, thinking that the consumer was only interested in the maximum cubic foot rating. They were right! However, people are becoming aware that thin walls mean thin insulation. Energy saving refrigerator/freezers using either thicker walls or urethane insulation are now available, and they consume only half as much electricity.

Americans have also been converted to the frost-free refrigerator in which hidden electric elements and fans are periodically switched on to remove the inevitable frost build-up. The refrigerator is thereby called upon to fight itself. Frost-free refrigerators consume 40% more electricity than the old fashioned manual defrost models did. The next time you are at Sears, ask to see the manual defrost models. They probably won't have one.

Another major waste of energy is loss of the refrigerated air. Hot air rises and cold air falls. When you open the refrigerator door, the cold air literally falls onto the floor. Stand in front of an open refrigerator with bare feet and see! Therefore, if you purchase a freezer, consider the chest type. When you open the lid, the cold air can't fall out. Also, plan ahead when opening the refrigerator door. Standing in front of an open refrigerator while you remember what you meant to take out of it is very wasteful.

4) Clothes dryer. As we mentioned before, venting electric dryers to the inside of the house in the winter recycles the energy for house heating. Convert to outside venting in summer. Two warnings: a) gas dryers must be vented outside; b) if venting inside results in fogging of window glass throughout the house, discontinue the practice because you may be damaging the inside of the walls by condensation.

In terms of efficiency, the last minutes of drying are much more expensive than the first. Remove the clothes while still damp. A winter house is so dry that the clothes will dry rapidly even piled up.

Best of all, however, is drying your laundry outside on a clothesline. If you've never slept in sheets dried outside in the breeze, you haven't lived. And it doesn't cost a cent or a kWh!

ENERGY CONSERVATION: THE HOUSEHOLD VIEW

The decision of one family to insulate its attic might not measurably affect the overall national consumption picture. However, a $10 million bond issue proposed in Maine to retrofit schools and public buildings can have substantial impact. Conservation measures taken in the home make economic sense. In addition, these small changes can initiate life style revisions of significant proportions. (For example, try not watching television for a two-week period to save energy.)

CONSERVATION MAKES SENSE TODAY

The 1976 Energy Research and Development Administration (ERDA) plan stressed conservation, a major change from previous policy. ERDA officials cite several key reasons for this dramatic change in policy:

1) Energy conservation would save two times as much energy as a comparable investment in new supplies.

2) Energy conservation stretches the earth's limited resource base of high quality fuels.

3) Energy conservation provides more valuable fossil fuel for less developed nations.

4) Energy conservation avoids environmental degradation.

FOOTNOTES

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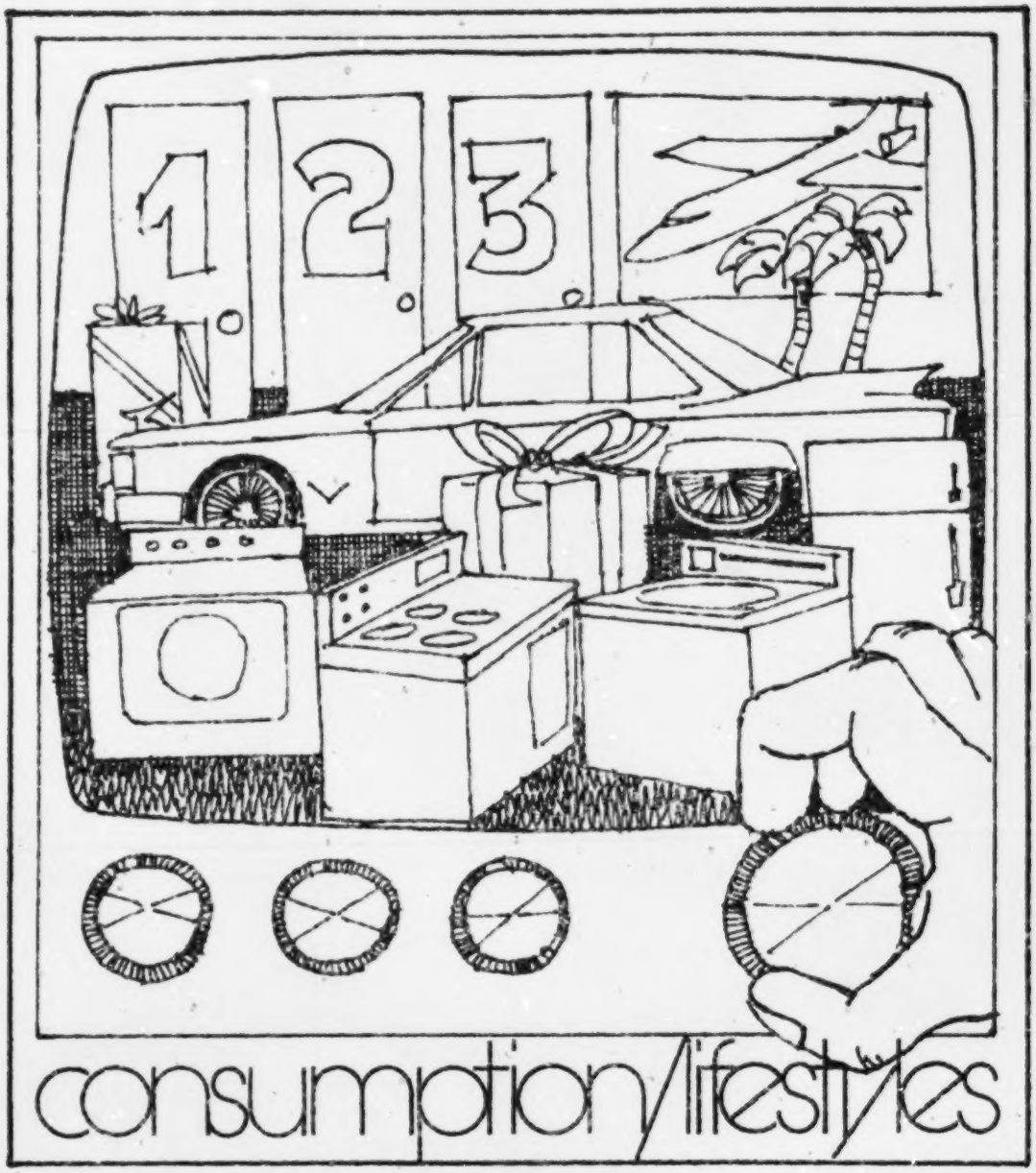

1°
2°
3°
consumption/lifestyles

CONSUMPTION/LIFE STYLE

FOR: Social Science Teachers

CONCEPTS: Gross National Product (GNP)
Renewable and non-renewable resources
Social values
Appropriate technology
Smaller (resource) pies

INTRODUCTION

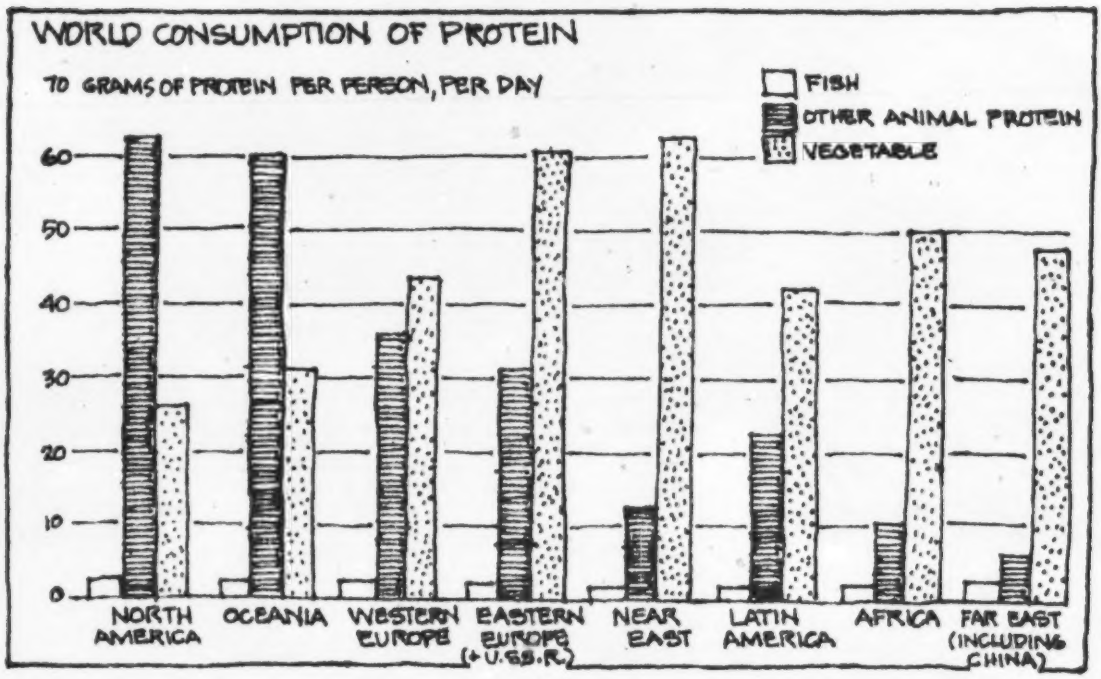
Over-consumption and the Energy Crisis: The Environmentalist's Perspective

Since World War II, America has built a powerful industrial complex that has allowed and encouraged record consumption. In June 1970, President Nixon rejoiced in his statement that, "Our free economic system has produced enormous disposable income in the world, and it is higher today than ever before in our history ... In the next five years, in real terms, the American consumer will be able to buy almost 20% more than he does today."[1]

Years later the trend that Nixon prophesied continues: we consume more and more. In his book, Overskill, Eugene Schwartz explains, "With 5.8% of the world's population living on 6% of the earth's land surface, the people of Americanconsume nearly 50% of the world's non-renewable mineral and fuel resources. If the rest of the world consumed as we Americans do, the present world annual rate of production of iron, copper, lead, zinc, tin, cement and salt would have to be increased well over 100 times -- a physical impossibility!"[2]

Our country's over consumption is most dramatic in the current food system. If all people in the world produced, processed, and consumed food the way Americans do, a full 80% of the total world energy budget would have to be devoted to this one pursuit. Few peoples around the world can eat as high off the hog as Americans do. In general, the wealthier the country, the more energy its typical diet contains. Per capita beef intake in the United States has more than doubled in the past decades.[3] Relative to the rest of the world, we consume animal protein with a ferocious appetite.

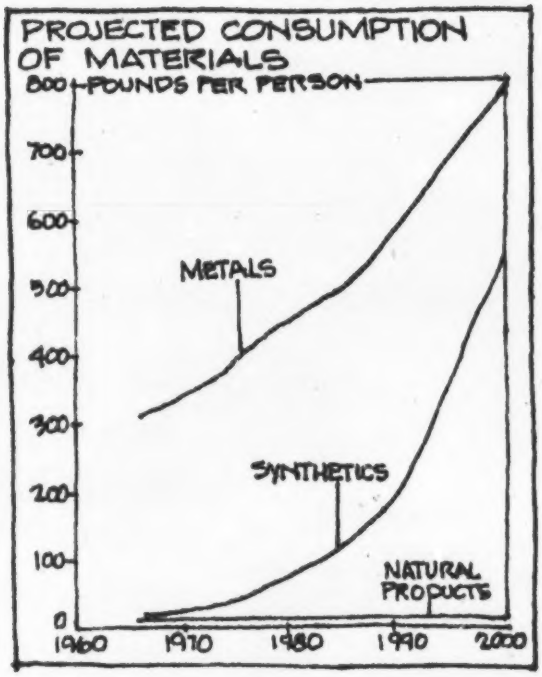
4



One-third of the world grain harvest is now channeled into feedlots to fatten cattle, even though feedlot beef has more saturated fat and less protein than grass-fed beef.[5]

WASTE

A by-product of this unchecked consumption is the generation of massive amounts of waste. Consumption of food in the United States increased by 2.3% by weight on a per capita basis between 1963 and 1971. In the same period the tonnage of food packaging increased 33.3% per capita and the number of food packages increased 38.8% per capita.[6] Every year each American generates approximately 1,100 pounds of trash. The switch of industry from natural (bio-degradable) materials to the more profitable (non-degradable) synthetics has hastened this build-up of environmentally destructive junk.



Can this consumptive life style be sustained? What alternatives exist in our present system of mass production and waste? Environmentalists hope to show the interconnectedness of man and the natural environment, and in so doing, to demonstrate that we are a part of a delicate web that we are irrevocably destroying. Perhaps a new set of economic assumptions needs to be developed to internalize some of the true costs of our present production systems. Devising a new economic values system, one which stresses energy conservation and environmental protection, is a major task facing today's policy makers.

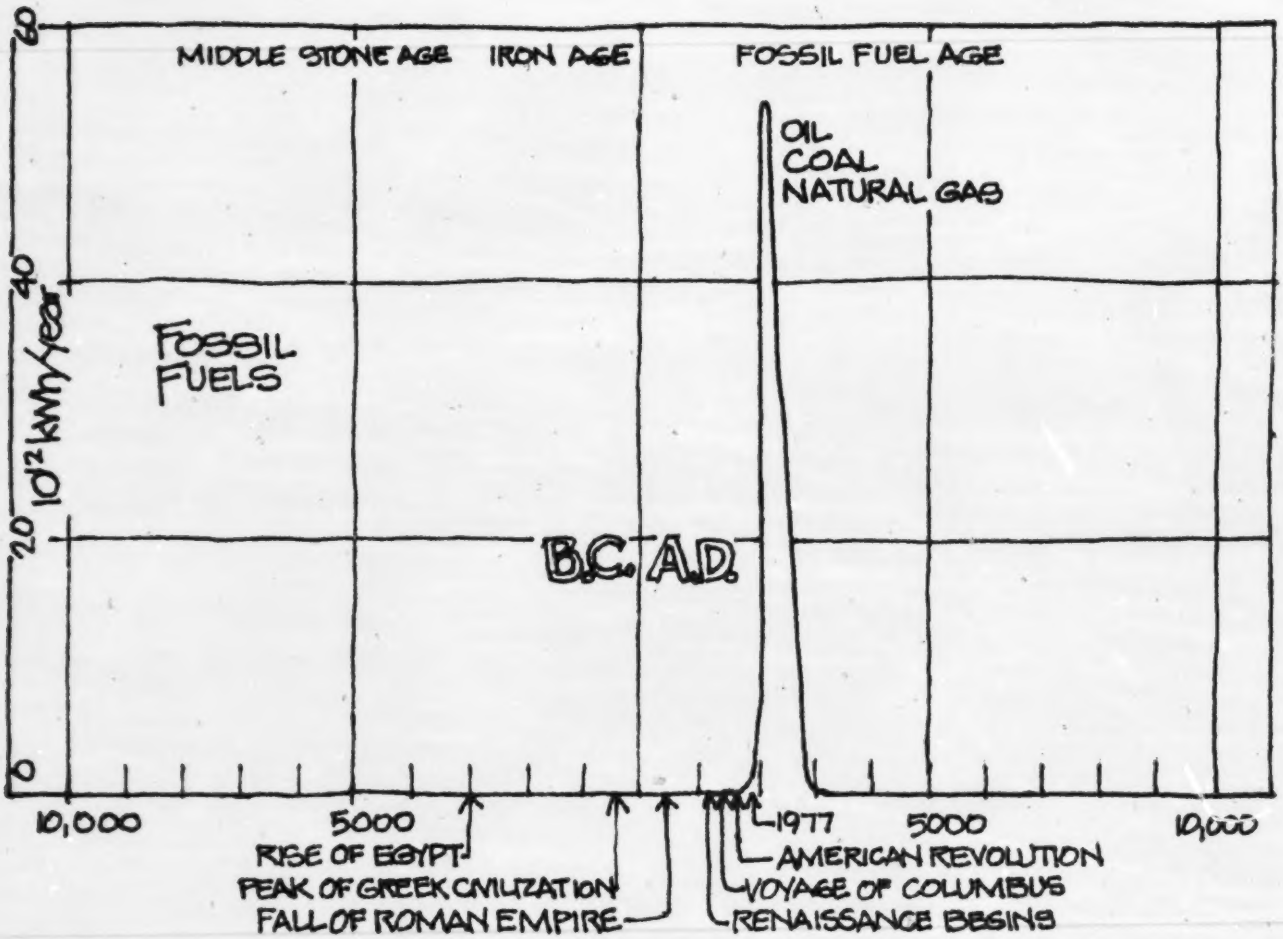
GROSS NATIONAL PRODUCT

For the past several decades, the health of a country's economy has been measured by its Gross National Product (GNP), i.e., the combined value of all its goods and services. Many economists feel that without an expansion of the GNP, a country's economy would stagnate and falter. Implicit in this economic assumption are several key value judgments which many Americans are beginning to question. Does the total monetary value of the goods and services truly relfect the quality of life in a particular society? Is more always better than less? Are there costs inflicted by our increased growth that do not figure into the cost/benefit analyses of the top decision makers? Who are the primary beneficiaries of this increased GNP?

The GNP provides an index of the quantity of goods and services available in a particular society. It does not, however, explain the relative distribution of such goods and services. To the extent that people perceive their personal wealth relative to that of their neighbors, greater attention should be paid to analyzing who gets what. Also, it is wrong to assume that, because people are consuming less goods through conventional means, the quality of life has declined. In other words, cultural, artistic, and spiritual pursuits cannot easily be included in GNP studies; however, they can, and do, substantially improve the quality of life in a society. Likewise, many life support tasks can be handled in the household through use of natural energy (e.g. human or solar) rather than the conventional methods. For example, drying the wash on the back yard clothes line, and canning one's own garden vegetables both make substantial energy savings, yet neither is fully accounted for in GNP reckonings.

FOSSIL FUEL ADDICTION

The unparalleled growth in our production capabilities can be attributed directly to our exploitation of fossil fuel reserves. Our agriculture system has switched from a soil resource base to one largely dependent upon oil. Likewise, our transportation system has been designed to run on a cheap, presumably inexhaustible supply of oil. The gas guzzling automobile is a dinosaur whose extinction is inevitable. Unfortunately, the layout of many of our cities falsely assumed the continued use of the private automobile. Making the transition to a post-petroleum era will not be easy. However, it is imperative that we recognize the folly of living off our capital energy resources while ignoring the self-sustaining natural energy flows. If we study a time line of energy use throughout history, we see that the fossil fuel era will end shortly and that the utilization of the earth's fossil fuels comprises a relatively brief period when viewed over the course of history.

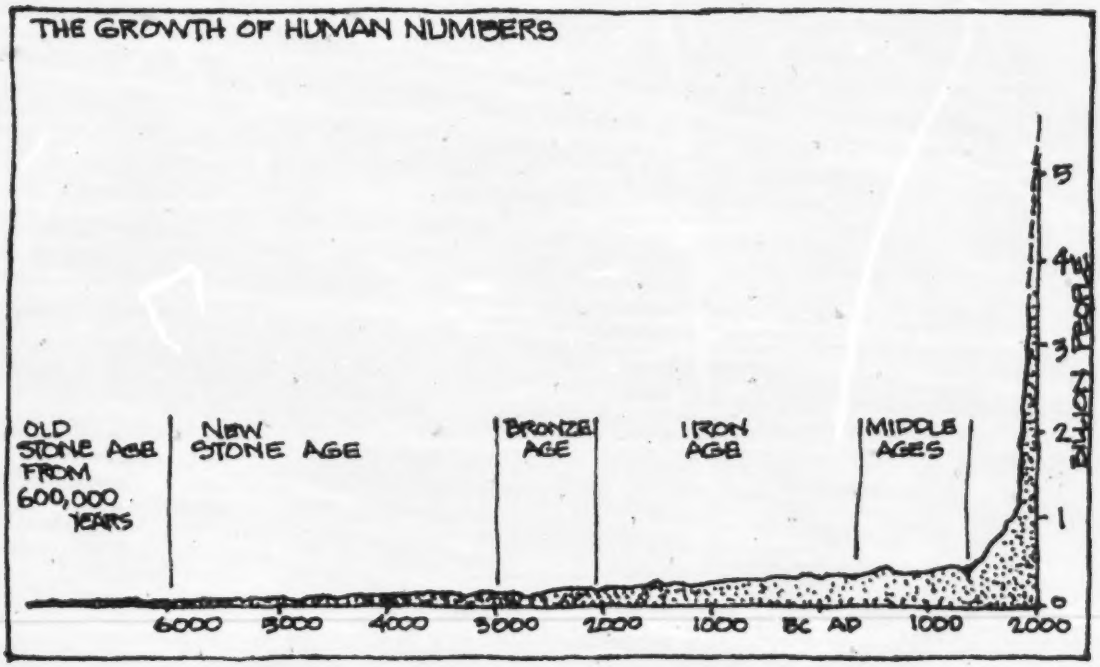


The primary task of future historians in reviewing the second half of the twentieth century will be to chronicle the economic, political and social birth pangs America experienced while moving out of the fossil fuel era. Just as King Cotton succumbed in the 19th century, so too must King Oil be replaced. The physical demands of the earth dictate this transition.

BIGGER PIES

Several "growth-advocating" economists suggest that if we continue to produce bigger industrial pies, then each individual country's piece will also get bigger. Their solution to the resource/energy problem is not to divide the existing resource production pie more equitably, but rather to make substantially larger pies so that the smallest piece will be appreciably larger. Can the earth support the manufacture of of these larger and larger pies? Are there upper limits to the number of people and the subsequent wear and tear the earth can withstand?

Population control is the ultimate environmental issue. An exponential increase in population will produce tremendous strains on our food supply systems. This increasing population will force the conversion of valuable farm land into housing developments. Even if we assume a doubling of food production per acre, no natural disasters, and conservative growth patterns, there will be less food per capita on a global scale available in the year 2000 than is available today. With one-quarter of the world's population now starving, this future prospect is indeed unsettling.



THE INCREASE OF POPULATION

IT TOOK FROM	FOR POPULATION TO REACH
the beginning of man to the Neolithic age	7,990,000 years to reach 10 million
Neolithic age to the birth of Christ	10,000 years to reach 300 million
birth of Christ to the days of Columbus.	1,500 years to reach 500 million
Columbus to 1850 A.D.	350 years to reach 1 billion
1850 to 1925 A.D.	75 years to reach 2 billion
1925 to 1962 A.D.	37 years to reach 2 billion
and will take to 1975	13 years to reach 4 billion
and from there to 1982	7 years to reach 5 billion

The American agricultural system and its offshoot for underdeveloped countries, the Green Revolution, depend heavily on fossil fuel inputs. The predominant agricultural trend in the twentieth century has been the replacement of sustainable human energy with non-renewable types of energy. The large concentrations of unemployed people in Western industrialized cities suggest that this trend has been socially destructive. A fuel crisis will mean a food crisis of unparalled proportions.

RENEWABLE RESOURCES

Fortunately, not all the earth's resources are non-renewable. We are not withdrawing wealth from a natural bank account that does not receive continual deposits. The natural cycles that have taken more than 4 1/2 billion years to evolve are the driving forces that sustain life on our spaceship earth. The photosynthetic process recycles CO_2, oxygen and water. The earth's ozone layer acts to shield and modulate the incoming and outgoing light and heat. Nitrogen-fixing bacteria help to regenerate the soil as organic materials decay. When man disrupts these natural cycles either wilfully or unknowingly, he jeopardizes the replenishing of his renewable resources.

In the interest of short term profit, industry has ignored the basic fundamental truism, a part of many native American philosophies: fertile land, fresh air, and clean water are without price; the earth does not belong to man, but, rather, man belongs to the earth. In their exuberance of production for production's sake, businesses have often ignored the harmful side effects of their activities. The social and environmental costs of polluting the air, or raising the temperature of our rivers, or annihilating a species have rarely been calculated into traditional cost/benefit analyses. A careful assessment of all costs will force businesses to rethink the advisability of producing new products. Someday, industrialists will begin to produce goods and services to fulfill genuine social needs, not just to make a profit.

The advocates of continued economic expansion and energy growth make one key miscalculation. Even if we develop an unlimited source of power which would theoretically allow us to produce our way out of the energy crisis, there will be insufficient supplies of the mineral reserves needed to make the machines and equipment to produce that power. Without extensive recycling projects, there simply will not be sufficient global supplies of the necessary mineral resources. It is foolish to assme the industry-wide acceptance of a mineral conservation-recycling ethic coupled with its opposite extreme, unlimited energy use.

Number of years known reserves will last if growth continues exponentially:[7]

RESERVES	YEARS
Aluminum	31
Copper	21
Gold	9
Lead	21
Mercury	13
Natural Gas	22
Petroleum	20
Silver	13
Tin	15
Zinc	18

The following advertisements point out the potential conflict between growth and non-growth advocates:

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SOCIAL VALUES

There do exist alternatives to the production system we now live with. People can decide to revert back to the use of goods and services whose impact on the natural environment is less harmful. The use of natural cloth fibers, natural foods, organic (soil-restoring) agricultural systems, wood and solar heating, walking and bicycling -- these life style changes are less taxing of our limited supplies of non-renewable resources. This switch back to a less energy intensive life style also revives more humane and less complicated technologies. Is it not easier to understand and participate in the heating of your home with wood rather than electricity from a nuclear fission plant?

Reverting to a life style in greater harmony with nature necessitates the spending of a great deal more time devoted to life support tasks. The fact that 51% of all families had gardens in 1976 suggests that the people of this country are either philosophically or economically motivated to return to basic life support tasks. The renaissance of owner-built homes, food cooperatives, and make-it-yourself clothing supply companies indicates that people want greater control of and input into those vital life support industries which heretofore (since World War II) have gone unchallenged. People are searching out more humane, less wasteful, more responsive institutions to accomplish life support tasks.

The basic issue is: can America adopt a more holistic, less environmentally destructive life style? Can those institutional barriers which inhibit this switch to a conservation ethic be overcome? First of all, Americans must recognize the urgency of environment-energy problems. The adoption of this new social ethic will be tantamount to a religious conversion. Second, the traditional modes of economic analysis need to be questioned. Perhaps a cultural or spiritual movement towards the solution of these problems, a campaign "the moral equivalent of war", will allow us to view the situation through new lights.

It is important that nostalgia for the past be tempered with a realistic acceptance of those technological advances that have improved the overall quality of life. For example, it is naive and irresponsible to advocate the return to a horse-powered society. The disease and pollution associated with that mode of transportation are usually forgotten today. What Americans need to do is to analyze all production technologies used in the past and compare them to those which are available today. A selection of those appropriate systems will help us to overcome the blind momentum of our current production/consumption system.

The Louis Harris Agency questions Americans on the following proposition:

> "Americans are 6% of the world's population, but consume 40% of the world's production of energy and raw materials. Do you feel that consuming that much is morally wrong or not?"
>
> The majority (61%) answered yes that is is morally wrong for us to use a disproportionate share of the world's resources. 9

The key question is how will this moral guilt be translated into policy, and how will those policies affect the American consumption/production ethic.

APPROPRIATE TECHNOLOGY

The increased technological sophistication of many industrial processes and the incredibly high capital costs allow only the largest corporations the opportunity to experiment with new production technologies and new products. The corner truck stop cannot compete with McDonald's because of that corporation's economies of scale. The dominance of a handful of large corporations stifles diversification and small scale enterprise.

Consider the following facts: 10

.....Exxon is the largest corporation in the world, with net assets exceeding 32 billion dollars.

.....A mere 20 companies control the 181 billion dollar transportation industry, a share equivalent to 18% of our GNP, yet these companies employ only 2.7% of the labor force.

.....29 corporations own 21% of all the cropland in America

.....The 8 largest oil companies control 64% of all proven oil reserves.

.....Between 1968 and 1974, the GNP increased more than $160 billion (real dollars), yet the average weekly earnings of the average worker remained the same ($103). Where did that wealth go?

To a large extent these corporations are able to dictate what and how much Americans consume. However, the American people are beginning to understand this corporate manipulation, as the recent ecological Bottle Bill victory in Maine pointed out. Industrialists can learn a valuable lesson from nature: species diversity leads to stability. Energy and product diversification should be a primary goal of a new production system. Putting all our eggs in the oil or nuclear basket makes us extremely vulnerable to foreign aggression.

A societal rethink of massive proportions is called for. As a society whose people are accustomed to a multitude of material possessions, unlimited mobility, and a production system which runs on massive amounts of energy, the task that lies before us is Herculean. The people of America must be given the opportunity to voice their opinions, to offer input into those decisions that affect us all.

On a personal level, the individual must understand the impact of particular consumption patterns. What are the economic and environmental effects of driving 65 mph or of purchasing an electric curling iron? How can each of us both positively change our own life style patterns and also influence the direction of our society as a whole? These are the essential questions people of all ages need to be asking.

The energy crisis is basically a crisis of over-consumption. We wallow in our wastes, e.g. smog clouds, polluted beaches, radioactive poisonings. We squander our valuable resources. In our mindless pursuit to have more and more, we forget that which is basic, that for which we have genuine need. The environmentalist's solution is to cut back on current consumption, develop more benign and appropriate technologies, explore alternative renewable sources of energy and stop to examine the moral poverty of our current production/consumption ethic. The bald eagle, the mud worms of Wiscasset, and Kate Furbish's lousewort can only wait patiently as Homo sapiens alone decide the fate of all earthly creatures.

FOOTNOTES

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